KMK | Keating, Muething & Klekamp PLL
ATTORNEYS AT LAW

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May 17, 2004

Via Federal Express

Chief, Environmental Enforcement Section
Environment and Natural Resources Division
U.S. Department of Justice
Box 7611 Ben Franklin Station
Washington, D.C. 20044-7611
Re: DOJ No. 90-11-2-06089

Compliance Tracker
Air Enforcement and Compliance Assurance Branch
U.S. Environmental Protection Agency
Region 5, AE-17J
77 West Jackson Boulevard
Chicago, Illinois 60604

Director, Office of Regulatory Enforcement
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
Mail Code 2241A
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Mr. Kevin L. Vuilleumier, Environmental Engineer
Air Enforcement and Compliance Assurance Branch
U.S. Environmental Protection Agency
Region 5-AE-17J
77 West Jackson Boulevard
Chicago, IL 60604-3507

Mr. Cary Secrest
U.S. Environmental Protection Agency
Ariel Rose Building, Room 2119
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20004

RECEIVED
MAY 18 2004
AIR ENFORCEMENT BRANCH,
U.S. EPA, REGION 5

RE: United States v. Buckeye Egg Farm, L.P., et al. – Civil Action 3:03 CV 7681. Request for Modification of Testing Schedule under Attachment A of Consent Decree

Dear Sir/Madam:

This letter is submitted on behalf of Ohio Fresh Eggs, LLC. In response to EPA's April 19, 2004 comment letter on the Proposed PM and Ammonia Control Plans, the purpose of this letter is to submit a detailed Quality Assurance Project Plan, and revised Proposed PM and Ammonia Control Plans (without previously provided attachments and exhibits) for EPA's review and approval. Also enclosed is Ohio Fresh Eggs' Certification for the revised Proposed Plans and the Quality Assurance Project Plan.

Should you need additional information, please contact me.

Very truly yours,

KEATING, MUETHING & KLEKAMP, P.L.L.

By: Brian Babb
Brian M. Babb

Enclosure

cc: Mr. Donald C. Hershey
Dr. Albert J. Heber
Mr. Richard L. Campbell

1271012.1

CERTIFICATION

I certify under penalty of law that this document and any attachments to it were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing and willful submission of a materially false statement.

OHIO FRESH EGGS, LLC

Donald C. Hershey

Donald C. Hershey, Manager

1232938.1

Quality Assurance Project Plan 1
For
Measurement and Control of Air Emissions from Laying Barns in Ohio

Department of Agricultural and Biological Engineering
Purdue University, West Lafayette, IN 47907-1146

June 3, 2004

APPROVALS

Signatures	Date
Mr. Donald Hershey, Ohio Fresh Eggs	
Cary Secrest Mr. Cary Secrest, US EPA Headquarters	Jun. 15, 2004
Kevin Vuilleumier Kevin Vuilleumier, US EPA Region 5	06/15/2004

FACSIMILE REQUEST AND COVER SHEET

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
AIR AND RADIATION DIVISION
77 WEST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604

TO: Brian Babb

OFFICE: Keating, Muething and Klekamp

PHONE # (513) 579-6963 MACHINE # (513) 579-6457

FROM: Kevin Vuilleumier

ORGANIZATION: AIR ENFORCEMENT AND COMPLIANCE ASSURANCE BRANCH

PHONE # (312) 886-6188 MACHINE # (312) 353-8289

DATE: 06/15/2004 NUMBER OF PAGES INCLUDING THIS COVER SHEET 02

COMMENTS: Please fax to Ron Hershey for signature. Once he signs, fax final back to me.

Kevin

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AIR ENFORCEMENT AND COMPLIANCE ASSURANCE BRANCH

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FACSIMILE REQUEST AND COVER SHEET

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
AIR AND RADIATION DIVISION
77 WEST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604

TO: Brian Babb

OFFICE: Keating, muething and Klekamp

PHONE # (513) 579-6963 MACHINE # (513) 579-6457

FROM: Kevin Vuilleumier

ORGANIZATION: AIR ENFORCEMENT AND COMPLIANCE ASSURANCE BRANCH

PHONE # (312) 886-6188 MACHINE # (312) 353-8289

DATE: 06/15/2004 NUMBER OF PAGES INCLUDING THIS COVER SHEET 02

COMMENTS: Please fax to Don Hershey for signature. Once he signs, fax final back to me.
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Office of Enforcement and Compliance Assurance
Office of Regulatory Enforcement
Air Enforcement Division

Ariel Rios Building Room 2119
1200 Pennsylvania Ave., N.W.
Washington, D.C 20004
Tel: 202.564.8661
Fax: 202.564.0053

Date: Jun 15

Fax To: Kevin Vuilleumier
Fax No.: 312.353.8289

From: Cary Secrest

Pgs. Total _2_

Message:

Please sign and fax to Don Hershey, then ask him to fax the final back.

Thx.

REVISED

PROPOSED

Ammonia Emissions Control Design and Implementation Plan

for

Ohio Fresh Eggs, LLC's Croton, Marseilles, and Mt. Victory, Ohio Facilities

May 2004

Submitted by:

Ohio Fresh Eggs, LLC
11212 Croton Road
Croton, Ohio 43013
740/893-7200 (telephone)
740/893-7204 (fax)

Table of Contents

Table of Contents
(continued)

LIST OF FIGURES

SECTION I. <u>INTRODUCTION</u>

Ohio Fresh Eggs, LLC recently acquired commercial egg-laying facilities from Buckeye Egg Farm, L.P. that are located in Croton, Licking County, Ohio ("Croton Facilities"), Harpster, Wyandot County, Ohio ("Marseilles Facilities"), LaRue, Hardin County, Ohio ("Mt. Victory Facilities"), which Facilities are subject to the requirements of the Consent Decree in <u>United States v. Buckeye Egg Farm, L.P., et al.</u>, United States District Court, Northern District of Ohio, Western Division, Civil Action No. 3:03CV7681. Attachment A of the Consent Decree requires that certain emission controls be installed at these Facilities if, based on testing, such controls are determined to be effective at reducing particulate matter and ammonia emissions from these Facilities. A copy of the Consent Decree, and the associated Attachment A and Exhibits 1-3 are attached for reference as Exhibit 1.

One of the emissions to be addressed under Attachment A of this Consent Decree is the reduction of ammonia (NH_3) generated from the deep-pit layer barns at these Facilities. The layer barns at the Croton Facilities are under a defined schedule to be converted from "deep-pit" manure layer barns to barns with "belt battery" manure handling systems. The belt battery layer barns emit lower concentrations of ammonia than the deep-pit layer barns since there is less manure in these types of barns and the manure has less moisture. There are no plans, nor requirements, to convert the deep-pit layer barns at the Mt. Victory and Marseilles Facilities to belt battery manure management systems. Ohio Fresh Eggs proposes to test the effectiveness of a manure enzyme additive to reduce ammonia emissions from the deep-pit layer barns at the Croton, Mt. Victory and Marseilles Facilities.

This Proposed Ammonia Emissions Control Design and Implementation Plan sets forth in detail how Ohio Fresh Eggs intends to test and implement the use of an enzyme additive to reduce ammonia emissions from the manure in the deep-pit layer barns at the Croton, Mt. Victory and Marseilles Facilities.

SECTION II. <u>BACKGROUND</u>

Generally, depending on the barn size, each deep-pit layer barn at the Croton, Mt. Victory and Marseilles Facilities, when at full capacity, houses either 68,885 or 97,627, 163,859, or 166,780 layer chickens, respectively. The layers excrete manure, which is accumulated in concrete pits beneath the layer cages in the deep-pit layer barns. The manure in the pits within the deep-pit layer barns is removed semi-annually, or during a change over in layers. In contrast, the belt battery layer barns each house approximately 102,098 or 140,000 birds, depending on the barn size and configuration, and manure is removed via covered conveyor belts on a daily basis for storage in separate manure storage buildings. Forced air is directed on the manure conveyer belts to help reduce the moisture content of the manure prior to storage in the manure storage buildings, which are emptied at least annually. The number of layers in the houses will change as a result of the UEP Guidelines.

SECTION III. <u>OVERVIEW</u>

Attachment A to the Consent Decree requires the submission of a Proposed Ammonia Emissions Control Design and Implementation Plan to the United States Environmental

Protection Agency for review and approval by March 15, 2004. Ohio Fresh Eggs intends to test the effectiveness of a commercially available enzyme additive to reduce ammonia emissions by 50% or more in its deep-pit layer barns. Initially, the effectiveness of the enzyme additive will be tested in a bench-scale study. If the test results show the additive is effective at reducing ammonia emissions from the layer barns by 50% or more, Ohio Fresh Eggs will test the effectiveness of the enzyme additive, on a trial basis, in one fully housed, deep-pit layer barn at the Mt. Victory Facilities. If test results demonstrate that the enzyme additive reduces ammonia levels by 50% or more, the enzyme additive will be used on an ongoing basis in all deep-pit layer barns at the Croton, Mt. Victory and Marseilles Facilities in accordance with the requirements of Attachment A. Attachment A to the Consent Decree also requires each layer barn at the Croton Facilities that is not converted to belt battery manure handling systems by December 31, 2004, to be subject to the ammonia testing and control requirements until such barns are converted to belt battery manure handling systems. Attached Figures Nos. 2 and 4 summarize the ammonia emission control requirements under Attachment A of the Consent Decree.

SECTION IV. AMMONIA CONTROLS

A. Product or System Design

1. *Enzyme Additive Product or System*

Ohio Fresh Eggs intends to use the Eco-Cure Enzyme Product, which is an enzyme activator, to reduce ammonia emissions from the deep-pit layer barns at the Croton, Mt. Victory and Marseilles Facilities. Eco-Cure is expected to substantially reduce ammonia emissions from the deep-pit layer barns. The manufacturer of this enzyme activator, Eco-Cure, Inc., claims that this product is highly effective in reducing ammonia emissions.

(a) Description of Product

Eco-Cure Enzyme Product is an organic enzyme activator that acts to immobilize ammonia (NH_3) to organic nitrogen (N). This enzyme activator is manufactured by Eco-Cure, Inc. The Material Safety Data Sheet for the Eco-Cure Enzyme Product is attached as Exhibit 2. The enzyme activator works by encouraging aerobic bacterial growth (as opposed to anerobic bacterial activity which promotes the production of ammonia) that consumes ammonia and other organic constituents in the manure.

(b) Explanation of Product Application

Eco-Cure is sold in solid form in 5 gallon containers that each weigh 22 pounds. One pound of the Eco-Cure concentrate is mixed with 32 gallons of dechlorinated water, or water with low chlorine levels. Eco-Cure specifies that the Enzyme Product is to be applied weekly. A copy of the manufacturer's instructions for the use of Eco-Cure is attached as Exhibit 3.

Subject to successful bench scale test results, within 60 days of EPA approval, Ohio Fresh Eggs intends to apply Eco-Cure manually, through the use of portable sprayers, in one (1) deep-pit layer barn at the Mt. Victory Facilities for a period of six (6) months to coincide with the Silsoe Secondary Test Method that will be performed at that barn and a separate control barn, from August 1, 2004 to January 31, 2005. Should the Secondary Test Method results confirm that use of the Eco-Cure reduces ammonia emissions in the deep-pit layer barns by 50% of more, within 60 days of EPA approval, the use of Eco-Cure will be implemented at all deep-pit layer barns in accordance with the requirements of Attachment A of the Consent Decree. In the event the Eco-Cure product is effective at reducing ammonia emissions, Ohio Fresh Eggs would likely evaluate the feasibility of installing and operating a fixed, automatic sprayer system to apply the Eco-Cure in deep-pit layer barns in lieu of the use of the portable sprayers. Written procedures and training will be provided to the employees that mix and apply the Eco-Cure product to ensure consistency in the concentration of Eco-Cure that is applied in the layer barns.

(c) Summary of Product Costs

The cost of Eco-Cure is $60 per pound or $1,320, plus shipping, per 5 gallon container. The estimated costs to use Eco-Cure in a deep-pit layer barn is $33 per week or $1,700 per year. The estimated annual cost for the equipment to apply the Eco-Cure is $500. The estimated annual labor cost to apply Eco-Cure is $1,500.

The manufacturer claims that the use of Eco-Cure will reduce pesticide use since the treated manure is a less attractive medium for flies. The estimated cost savings associated with the use of Eco-Cure, due to the potential reduced use of pesticides, is unknown. Because Ohio Fresh Eggs very recently acquired ownership of the Facilities, it has not had sufficient time to track pesticide use or costs at these Facilities and the estimated pesticide cost savings may be speculative.

(d) Description of Expected Emissions Reduction

Only very limited, mostly anecdotal, information is available from the manufacturer on the effectiveness of Eco-Cure's enzyme activator in reducing ammonia emissions. The information is attached for reference as Exhibit 4. No analytical data from the manufacturer appears to be available which shows the enzyme activator either will or will not reduce ammonia emissions by 50% or more. However, limited analytical information concerning the use of the enzyme activator does indicate that Eco-Cure may be effective in reducing ammonia odors and concentration. Copies of this information is attached as Exhibit 5. The manufacturer claims that 85 egg growers in the United States use Eco-Cure to reduce ammonia emissions, and that Eco-Cure users include Rose Acre Farms, Sparboe, ISE Newberry Inc., Valley Fresh Farms, and Tyson Foods. The manufacturer did not have or was not willing to provide any additional documents about the effectiveness of the use of Eco-Cure at these commercial facilities.

(e) Contract, Purchase and Implementation Schedule

The cost of the Eco-Cure enzyme activator is $60 per pound and is only available through Eco-Cure, Inc. According to the manufacturer, Eco-Cure is readily available for commercial use, subject to purchase order approval and shipping time. Ohio Fresh Eggs will order a sufficient quantity of Eco-Cure for the bench scale study upon approval of the Ammonia Control Plan. Eco-Cure is expected to be delivered to Ohio Fresh Eggs within two (2) weeks of ordering. Sprayer equipment to apply the enzyme additive is readily available and will be purchased by Ohio Fresh Eggs. Ohio Fresh Eggs expects that it may need 60 to 90 days to adjust the use of Eco-Cure to maximize its effectiveness.

(f) Reporting and Recordkeeping

As required by Attachment A of the Consent Decree, Ohio Fresh Eggs will timely submit the Eco-Cure test results from the bench scale and Secondary Test Method to EPA for review and approval. During the Secondary Test Method period, Ohio Fresh Eggs will maintain an Enzyme Activator Log to record the frequency and quantity of application of the enzyme activator. A sample Enzyme Activator Application Log is attached as Exhibit 6. These Logs will be reviewed on a weekly basis to ensure the enzyme additive is timely and properly applied in the deep-pit layer barns. These Logs will be summarized in the quarterly reports that are submitted to EPA. The quarterly reports will summarize the status of the Eco-Cure testing and implementation. Should the Secondary Test Method results confirm the effectiveness of the enzyme activator, and EPA approve facility-wide application, the Enzyme Activator Application Log will be maintained to monitor enzyme activator usage in the deep-pit layer barns at the Croton, Mt. Victory and Marseilles Facilities.

(g) Description of Expected Emissions or Wastes

According to Eco-Cure's manufacturer, the use of the enzyme activator substantially reduces the emissions of ammonia and hydrogen sulfide from the manure, and the only anticipated by-products or wastes generated from the use of Eco-Cure are carbon dioxide and water. It is possible that since the enzyme activator accelerates microbiological activity, which reduces the organic matter in the manure, that the use of Eco-Cure could concentrate certain nutrients in the remaining manure, such as nitrogen. Ohio Fresh Eggs will test the nutrient content in the manure prior to disposal or sale to determine if the Manure Management Plans for the Facilities need to be revised.

B. Testing

Ohio Fresh Eggs intends to test the effectiveness of the Eco-Cure enzyme activator in accordance with the requirements of Attachment A of the Consent Decree. Details about test parameters, quality assurance and quality control and data analysis, assessment and interpretation are included in the Quality Assurance Project Plan.

C. Implementation

Subject to EPA's approval of the test results from the bench scale study, and subsequently, if approved, the test results from the Secondary Test Method, Ohio Fresh Eggs will commence the use of the enzyme activator product, in accordance with the timetable and terms set forth in Attachment A of the Consent Decree, in all operational deep-pit layer barns at the Croton, Mt. Victory and Marseilles Facilities.

SECTION V. CONCLUSION

Ohio Fresh Eggs proposes to test the effectiveness of the use of a commercially available enzyme activator, Eco-Cure, to reduce ammonia emissions from its deep-pit layer barns at its Croton, Mt. Victory and Marseilles Facilities. Should bench scale tests and Secondary Test Method confirm that the use of the enzyme activator is effective in reducing ammonia emission by 50% or more, the enzyme activator will be used on an ongoing basis at all deep-pit layer barns in accordance with the requirements of Attachment A of the Consent Decree.

1283346.1

REVISED

PROPOSED

Particulate Matter Emissions Control Design and Implementation Plan

for

Ohio Fresh Eggs, LLC's Croton, Marseilles, and Mt. Victory, Ohio Facilities

May 2004

Submitted by:

Ohio Fresh Eggs, LLC
11212 Croton Road
Croton, Ohio 43013
740/893-7200 (telephone)
740/893-7204 (fax)

Table of Contents

Table of Contents
(continued)

Page

LIST OF FIGURES

SECTION I. INTRODUCTION

Ohio Fresh Eggs, LLC recently acquired commercial egg-laying facilities from Buckeye Egg Farm, L.P. that are located in Croton, Licking County, Ohio ("Croton Facilities"), Harpster, Wyandot County, Ohio ("Marseilles Facilities"), LaRue, Hardin County, Ohio ("Mt. Victory Facilities"), which Facilities are subject to the requirements of the Consent Decree in United States v. Buckeye Egg Farm, L.P., et al., United States District Court, Northern District of Ohio, Western Division, Civil Action No. 3:03CV7681. Attachment A of the Consent Decree requires that certain emission controls be installed at these Facilities if, based on testing, such controls are determined to be effective at reducing particulate matter and ammonia emissions from these Facilities. A copy of the Consent Decree, and the associated Attachment A and Exhibits 1-3, are attached for reference as Exhibit 1.

One of the emissions to be addressed under Attachment A of this Consent Decree is that of particulate matter ("PM"), which is generated by the layer barns at these Facilities. The layer barns at the Croton Facilities are under a defined schedule to be converted from "deep-pit" manure layer barns to barns with "belt battery" manure handling systems. The belt battery layer barns emit lower concentrations of PM than the deep-pit layer barns since the manure is continuously removed to a confined storage area with no ventilation discharge, thus eliminating a particulate generation point in these types of barns. There are no plans, nor requirements, to convert the deep-pit layer barns at the Mt. Victory and Marseilles Facilities to belt battery manure management systems. Ohio Fresh Eggs proposes to test the effectiveness of a Particulate Impaction System, and other emissions controls, to reduce PM emissions from the layer barns at the Croton, Mt. Victory and Marseilles Facilities.

This Proposed Particulate Matter Emissions Control Design and Implementation Plan sets forth in detail how Ohio Fresh Eggs intends to test and verify control efficiency of a particulate impaction media, referred to as the "Particulate Impaction System" or "curtains", as the primary control measure. In addition, other emission process control measures such as feedstock and bird type will be modified, to help reduce PM emissions from the layer barns at the Croton, Mt. Victory and Marseilles Facilities. Once the emission control measures have been proven effective then they will be implemented at these Facilities.

SECTION II. BACKGROUND

Generally, depending on the barn size, each deep-pit layer barn at the Croton, Mt. Victory and Marseilles Facilities, when at full capacity, houses either 68,885 or 97,627, 163,859, or 163,859 or 166,780 layer chickens, respectively. The primary sources of particulate matter emissions from the layer barns are believed to be the chickens, manure piles, feed fines and feathers from the layers. Ventilation fans are used in the barns to maintain proper ventilation rate and control temperature, and ostensibly facilitates the emission of particulate matter from the layer barns. The layers excrete manure, which is accumulated on concrete floors beneath the layer cages in the deep-pit layer barns. The manure collected in the pits in this type of layer barn is removed semi-annually, or during a change over in layers. In contrast, the belt battery layer barns each house approximately 102,098 or 140,000 birds, and manure is removed via covered conveyor belts on a daily basis for storage in separate manure storage buildings. Forced air is directed on the manure conveyer belts to help reduce the moisture content of the manure prior to storage in the manure storage buildings, which are emptied at least annually.

SECTION III. OVERVIEW

Attachment A to the Consent Decree requires the submission of a Proposed Particulate Matter Emissions Control Design and Implementation Plan to the United States Environmental Protection Agency for review and approval by March 15, 2004. Ohio Fresh Eggs intends to test the effectiveness of an innovative, Particulate Impaction System, which was successfully tested on a poultry operation in Germany, and other emission control measures, to reduce PM emissions from the deep-pit layer barns at the Mt. Victory and Marseilles Facilities.

Initially, the control efficiency of the Particulate Impaction System will be evaluated during a 7-day test on one (1) fan at a deep-pit layer barn at the Mt. Victory Facilities. If the test results indicate the Particulate Impaction System is effectively controlling PM emissions from the layer barns, Ohio Fresh Eggs will install the Particulate Impaction System on a trial basis, in one fully housed, deep-pit layer barn at the Mt. Victory Facilities and evaluate its performance and collect emission data to verify yearly emission rates over a six-month period using the Silsoe Secondary Test Method. In addition, the effect of process PM control measures such as the use of a new variety of chickens and feed will be evaluated during the EPA Method 5 and Silsoe Secondary Method testing in a belt battery barn at the Croton Facilities. If results of these tests demonstrate that the Particulate Impaction System, and other emission controls, adequately reduce PM levels, the Particulate Impaction System, and other emission controls, will be implemented in the layer barns at the Croton, Mt. Victory and Marseilles Facilities in accordance with the requirements of Attachment A. Attachment A to the Consent Decree also requires each deep-pit layer barn at the Croton Facilities, which is not converted to belt battery manure handling systems by December 31, 2005, to be retrofitted with the approved Particulate Impaction System, and other emission controls, until such barns are converted to belt battery manure handling systems. Attached Figures Nos. 1 and 3 summarize the PM emission control requirements under Attachment A of the Consent Decree.

SECTION IV. PARTICULATE MATTER CONTROLS

A. Product or System Design

Ohio Fresh Eggs proposes to use as the primary particulate control the Particulate Impaction System. The impaction system works on the principal of inertial separation, particles in the gas stream are removed by imparting a centrifugal force on the particles, this force is induced by pulling the particulate laden air through a series of spatially designed entrance holes on one side of the media at a sufficient velocity to induce particle impaction on the collection sector of the device before the gas then exits at spatially designed exhaust ports. This control was selected based on its collection efficiency capabilities for small particles, initial cost and minimal operational and maintenance costs, and the physico-chemical characteristics (i.e., size, shape, density, and agglomeration tendencies) of the site particulate matter. The system was successfully tested in Germany where test results indicated total TSP reductions of about 74% and PM10 reductions of about 65-70%. In addition, secondary process control measures such as a new variety of chicken and feed, an enzyme activator product, and operational controls on ventilation fans, to reduce PM emissions from the layer barns at the Croton, Mt. Victory and Marseilles Facilities, as required under Attachment A of the Consent Decree. The Particulate Impaction System, and other emission control measures, are expected to substantially reduce PM emissions from the deep-pit layer barns. The manufacturer of the Particulate Impaction System, Big Dutchman, believes that this System will be effective in reducing PM emissions. The enzyme activator product is being tested to evaluate its effectiveness in reducing ammonia emissions, but a secondary benefit is expected to be a reduction in PM emissions.

(a) Description of System/Product

(i) Particulate Impaction System. The Particulate Impaction System is a physical structure that resembles non-rigid ceiling-to-floor curtain/filter combination curtains, which will be constructed parallel to the manure pit sidewalls and at a proper distance from the discharge fans in the deep-pit layer barns. The collector sections of these curtains reduce PM emissions by removing airborne particulate matter via inertial separation and impaction then the air is exhausted via the ventilation fans from the barns. The Particulate Impaction System will be constructed with a winch system so that the System can be raised or lowered depending on the volume of manure in the manure pits. The use of this winch system is necessary to limit manure contact with the System to prevent damage. The lower portion of the curtain will consist of heavy plastic to prevent air flow through it and will be weighted at the bottom to limit movement of the lower curtain. The upper portion of the curtain will be comprised of a spatially designed perforated cardboard media with 90 degree contours which create sudden changes in airflow direction and force particles to impact on the media. When cleaned by vibration the particles drop out into a collection tray inside at the bottom of the impaction system. This System is manufactured by Big Dutchman. The general design of the Particulate Impaction System is attached as Exhibit 2.

(ii) New Layer Variety. Ohio Fresh Eggs proposes to introduce a new variety of layer chicken into the layer barns that hopefully will reduce PM emissions. The chickens are known as "Hyline W-36s," and are less active than the current variety. Recent research at Purdue University has shown that PM emissions are significantly influenced by bird activity. PM emissions at night when the layers are sleeping are 40 to 50% of daytime emissions.

(iii) New Feed. Ohio Fresh proposes to introduce a new type of feed into the layer barns that it believes will generate less dust. Research at Kansas State University has shown that diets with greater concentrations of oils, either as an amendment or through the use of high oil corn, will reduce PM emissions. The typical composition of the new feed will include 3% to 4% fat to reduce feed fines.

(iv) Enzyme Activator. Ohio Fresh Eggs proposes to use Eco-Cure Enzyme Product in the layer barns to reduce ammonia emissions, but it is expected that the use of this enzyme activator will also reduce PM emissions.

When applied the formulation causes a crust to form on the outside surface of the manure pile. This crust acts to agglomerate the particles thus reducing their ability to be entrained by the airflow movement over the pile. The use of Eco-Cure is described in the Ammonia Control Plan.

(v) Ventilation Fan Operation Control. Ohio Fresh Eggs proposes to purchase and install computer software that will monitor ventilation fan operation in one of the layer barns for six months. Ohio Fresh Eggs will analyze this data to determine the number of operating fans, duration of fan operation to calculate actual yearly PM emissions from the barns.

(b) Explanation of Particulate Impaction System Use

Subject to completion of the 7-day test results of the effectiveness of the Particulate Impaction System in reducing PM emissions, within 60 days of EPA approval of the test results, Ohio Fresh Eggs intends to install and operate the Particulate Impaction System in one (1) deep-pit layer barn at the Mt. Victory Facilities for a period of six (6) months to coincide with the Silsoe Secondary Test Method that will be performed at that barn, and a separate control barn at Mt. Victory, from August 1, 2004 to January 31, 2005. Installation of the Particulate Impaction System will commence within forty-five (45) days of EPA's approval, but will be completed before August 1, 2004. Should the Secondary Method Test results confirm that use of the Particulate Impaction System reduces PM emissions in the deep-pit layer barns to satisfactory levels, within 60 days of EPA approval, the installation of the Particulate Impaction System will commence at the deep-pit layer barns in accordance with the requirements of Attachment A of the Consent Decree. Ohio Fresh Eggs will complete installation of the curtains at the Mt. Victory and Marseilles facilities within one (1) year of EPA's approval of the Secondary Method Test results. Installation of the curtains will proceed with diligence throughout the required barns, but installation may be scheduled to coincide with flock changeover or other improvements. Written procedures and training will be provided to the employees that ensure consistency in the operation and maintenance of the Particulate Impaction System in the layer barns.

(c) Summary of Particulate Impaction System Costs

The cost to purchase and install the Particulate Impaction System is estimated at $22,000 per barn. The estimated annual labor cost to maintain the Particulate Impaction System, in the layer barns at the Croton, Mt. Victory, and Marseilles Facilities is $1,500 and maintenance of the partition is estimated at $3,000 per year.

(d) Description of Expected Emissions Reduction

Very limited information is available from the manufacturer on the effectiveness of the Particulate Impaction System in reducing PM emissions. This emission control system is very new and now being tested by the manufacturer. However, limited test data concerning the use of the Particulate Impaction System does indicate that the curtains may be effective in reducing total TSP emissions by 74% and PM 10 fraction by 65 to 70%. Copies of this information is attached as Exhibit 3. Because of the recent development of the impaction media, the manufacturer did not have or was not willing to provide any additional documents about the effectiveness of the use of Particulate Impaction System in reducing PM emissions at commercial egg-laying facilities.

(e) Contract, Purchase and Implementation Schedule

The impaction media is only available through Big Dutchman (P.O. Box 1183, 49630 Vechta, Germany or P.O. Box 1017, Holland, MI 49422-1017). According to Big Dutchman, the impaction media is available for commercial use, subject to purchase order approval and shipping time. Ohio Fresh Eggs will order a sufficient quantity of the impaction media for the PM emission tests upon approval of the PM Control Plan. The impaction media for the 7-day test and full installation in one layer barn has been ordered and is expected to be delivered to Ohio Fresh Eggs within thirty (30) days. Ohio Fresh Eggs expects that it may need thirty (30) days to adjust the Particulate Impaction System to maximize its effectiveness.

(f) Reporting and Recordkeeping

As required by Attachment A of the Consent Decree, Ohio Fresh Eggs will timely submit the 7-day test results, the Method 5 Test results, and the Secondary Test Method results to EPA for review and approval. During the Secondary Test Method period, Ohio Fresh Eggs will maintain an Operation and Maintenance Log to document maintenance, repair, and adjustments to the Particulate Impaction System and other approved emission controls at the Croton, Mt. Victory, and Marseilles Facilities. A sample Operation and Maintenance Log is attached as Exhibit 5. These Logs will be reviewed on a weekly basis to ensure the Particulate Impaction System is properly maintained and operated in the deep-pit layer barns and that the other approved emissions controls are consistently and properly used. These Logs will be summarized in the quarterly reports that are submitted to EPA. The quarterly reports will summarize the status of the PM emission control tests and implementation. Should the Secondary Test Method results confirm the effectiveness of the Particulate Impaction System, and EPA approve facility-wide application, the Log will be maintained to monitor operation of the Particulate Impaction System and other emission controls in the layer barns at the Croton, Mt. Victory and Marseilles Facilities.

(g) Description of Expected Ammonia Emissions or Wastes

According to the manufacturer of the Particulate Impaction System, the use of the Particulate Impaction System should substantially reduce the emission of particulate matter from the deep-pit layer barns. The only anticipated by-products or wastes generated from the use of Particulate Impaction System is dust or particulate matter collected by the Particulate Impaction System. The dust will be periodically deposited onto, incorporated into, and disposed along with the stored manure.

B. PM Testing

Ohio Fresh Eggs intends to test the effectiveness of the Particulate Impaction System, and other approved emission controls, in accordance with the requirements of Attachment A of the Consent Decree. The following testing protocols are intended to be used.

1. *Particulate Impaction System Test Protocol*

Within thirty (30) days of EPA's approval of the PM Plan, Ohio Fresh Eggs will install a Particulate Impaction System at one ventilation fan in layer barn No. 2, which is a deep-pit layer barn. A 7-day test of the Particulate Impaction System at layer barn No. 2 at the Mt. Victory Facilities will be conducted by Purdue University consistent with the Quality Assurance Project Plan, and within the time frames set forth in Attachment A to the Consent Decree. The Particulate Impaction System will be installed consistent with the manufacturer's instructions and Exhibit 1 to Attachment A of the Consent Decree. Test results will be submitted as required under Attachment A to the Consent Decree.

2. *Method 5 Test Protocol*

By May 15, 2004, Ohio Fresh will complete a 5-day, EPA Method 5 Test program consisting of 15 one hour tests, (3 per day at selected activity intervals) of a belt battery layer barn at the Croton Facilities, which barn will house a new variety of layer chickens, known as "W-36's", which are believed to be a calmer layer, and generate less dander and dust, and will be fed a new type of feed that is expected to generate less dust because of its composition and grind. This Method 5 Testing will be conducted by a qualified professional consistent with the Quality Assurance Project Plan. The testing will be performed in layer barn No. 45, which is a belt battery barn, of similar design, construction, and number of chickens as the previous Method 5 Testing conducted at the Croton Facilities.

3. *Secondary Test Method Protocol*

(a) Mt. Victory

A Secondary Test Method of PM emissions in a deep-pit layer barn, in which the Particulate Impaction System has been installed, will be conducted by Purdue University consistent with the Quality Assurance Project Plan. Subject to EPA's approval of the 7-day tests on the effectiveness of the Particulate Impaction System, Ohio Fresh Eggs will install the Particulate Impaction System in one (1) deep-pit layer barn at the Mt. Victory Facility in accordance with the requirements in Attachment A of the Consent Decree. The Particulate Impaction System will be installed in layer barn No. 2, at the Mt. Victory Facilities, which is a deep-pit barn. Layer barn No. 1 at the Mt. Victory Facilities, which is a deep-pit barn, will be the "control" barn during the Secondary Method Test. No enzyme activator or curtain will be used in the "control" barn during the Secondary Test Method period. Both test barns at the Mt. Victory Facilities are of comparable age, design, and chicken population. Ohio Fresh Eggs intends to commence application of the enzyme activator in test barn No. 2 prior to commencement of the Secondary Test Method in order to ensure optimal performance of the enzyme activator during the Test. Installation of the Particulate Impaction System will be installed within forty-five (45) days of EPA approval, but before August 1, 2004.

The Particulate Impaction System will be installed and operated in accordance with the manufacturer's instructions and guidelines in the deep-pit barn where the effectiveness of the enzyme activator is also being tested throughout the 6-month test period.

05/17/2004 12:09 PM

Quality Assurance Project Plan

Project: Measurement and Control of Air Emissions from Laying Barns in Ohio

Sponsor: Ohio Fresh Eggs, LLC

Albert J. Heber

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Albert J. Heber, Principal Investigator, Purdue University

(b) Croton Facility

Subject to EPA's approval of the Method 5 Test results, Secondary Test Method of PM emissions in a belt battery layer barn in which the new feed and chicken variety are being tested will be conducted by Purdue University consistent with the Quality Assurance Project Plan. Subject to EPA's approval, for purposes of preparing for the Secondary Test Method, Ohio Fresh Eggs intends to switch to a new variety of layer chickens, known as "W-36s", and a new type of feed prior to the commencement of the Secondary Test Method in order to best evaluate conditions representative of the use of new birds and feed. The Secondary Test Method will be performed in layer barn No. 45 at the Croton Facilities, which is a belt battery layer barn. This new type of feed and variety of layer will be used throughout the Secondary Test Method period at the Croton test barn. Barn No. 45 is similar to the design of the barn and number of chickens that were tested under the Secondary Method in August and September, 2003.

(c) Test Parameters

Details about test parameters, quality assurance and quality control and data analysis, assessment and interpretation are included in the Quality Assurance Project Plan.

C. Implementation

Subject to EPA's approval of the 7-day test and Method 5 Test results, and subsequently, if approved, the results from the Secondary Test Method, Ohio Fresh Eggs will commence the installation and operation of the Particulate Impaction System, in accordance with the timetable and terms set forth in Attachment A of the Consent Decree, in all operational deep-pit layer barns at the Croton, Mt. Victory and Marseilles Facilities. Subject to EPA's approval of the Method 5 and Secondary Test Method test results from the Croton barn, Ohio Fresh Eggs will implement the other approved PM emission controls at the Croton Facilities. For any deep-pit layer barns at the Croton Facilities that are not converted to a belt battery manure handling system by December 31, 2005, Ohio Fresh Eggs will retrofit such barns with the Particulate Impaction System. The installation of the Particulate Impaction System will be completed in such barns on a sequential basis at an average rate of one barn every twenty-one (21) days.

SECTION V. CONCLUSION

Ohio Fresh Eggs proposes to test the effectiveness of the use of a Particulate Impaction System to reduce PM emissions from its deep-pit layer barns at its Croton, Mt. Victory and Marseilles Facilities. Ohio Fresh Eggs also proposes to test the effectiveness of using a new bird variety and a new feed ration to reduce PM emissions. Should the results of the 7-day test, the Method 5 Test, and the Secondary Test Methods confirm that the use of the Particulate Impaction System and other emission controls are effective in reducing PM emission, the Particulate Impaction System, and other emission controls, will be installed and operated at the layer barns in accordance with the requirements of Attachment A of the Consent Decree.

Quality Assurance Project Plan [1]

For

Measurement and Control of Air Emissions from Laying Barns in Ohio

Department of Agricultural and Biological Engineering
Purdue University, West Lafayette, IN 47907-1146

May 7, 2004

APPROVALS

Signatures	Date
______________________ Mr. Donald Hershey, Ohio Fresh Eggs	________
______________________ Mr. Cary Secrest, US EPA Headquarters	________
______________________ Kevin Vuilleumier, US EPA Region 5	________

1 Principal Author: A.J. Heber, Agricultural and Biological Engineering Purdue University, West Lafayette, IN 47907-1146.

Table of Contents

QAPP Distribution List

Albert Heber	Purdue University
Lingying Zhao	Ohio State University
Don Hershey	Ohio Fresh Eggs
Ron Flory	Ohio Fresh Eggs
Brian Babb	Keating, Muething & Klekamp, P.L.L.
Cary Secrest	U.S. EPA Enforcement Division
Kevin Vuilleumier	U.S. EPA Region 5

1. Project Management

1.1. Project/Task Organization and Schedule

Albert Heber, Purdue University, is responsible for overall project management and for coordinating administrative logistics, including implementing the sub-contract with Ohio State University, filing of project reports, and management of financial resources. He is also responsible for directing the technical aspects of the project including creating, updating, distributing and implementing the quality assurance project plan, specifying instrumentation and equipment, and analyzing the data.

1.1 Personnel and Agencies Involved

Name	Affiliation	Office Phone	Cell Phone	E-mail/Cell phone
Albert Heber	Purdue University	765-494-1214	765-412-4201	heber@purdue.edu
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Lingying Zhao	Ohio State University	614 292-2366	614-598-8952	zhao.119@osu.edu
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Cary Secrest	EPA Enforcement Div.	202-564-8661	202-236-3499	secrest.cary@epa.gov

1.2 Personnel Responsibilities/Project Organization

Project Leader	Heber
Quality Assurance Project Plan (QAPP)	Heber
QAPP Review/Approval	Secrest, Bagg
Field Support	Flory/Sun
Obtain Access Agreements	Heber
Internal QA/QC Audits of Field Tests	Heber
External Field Oversight	Heber, Zhao
Media Inquiries	Heber
Field Data Analysis	Heber/Lim
NH_3 Data Reporting	Heber/Ni
PM Data Reporting	Heber/Lim
Data Compilation/Final Report	Heber/Ni/Lim
Final Report Review & Approval	Babb/Hershey/Secrest/Vuilleumier/Heber

1.3 Project Schedule (Mar. 1, 2004 to June 30, 2005)

Month	M04	A04	M04	J04	J04	A04	S04	O04	N04	D04	J05	F05	M05	A05
Set up labs	x	x	x	x										
QAPP, SOP	x	x	x											
Install labs					x									
Collect data						x	x	x	x	x	x			
Analyze data						x	x	x	x	x	x	x	x	x
Prepare report									x	x	x	x	x	x

1.2 Problem Definition/Background

Ohio Fresh Eggs, LLC recently acquired commercial egg-laying facilities from Buckeye Egg Farm, L.P. that are located in Croton, Licking County, Ohio ("Croton Facilities"), Harpster, Wyandot County, Ohio ("Marseilles Facilities"), LaRue, Hardin County, Ohio ("Mt. Victory Facilities"), which facilities are subject to the requirements of the Consent Decree in United States v. Buckeye Egg Farm, L.P., et al., United States District Court, Northern District of Ohio, Western Division, Civil Action No. 3:03CV7681.

Attachment A of the Consent Decree requires that certain emission controls be installed at these facilities if, based on testing, such controls are determined to be effective at reducing particulate matter and ammonia emissions from these facilities.

1.3 Project/Task Description

1.3.1 Project Objectives

The objectives of this study are to:

- Evaluate an enzyme-based manure additive for reducing ammonia from chicken litter.
- Quantify and characterize baseline particulate (PM) and NH_3 emissions rates for two types of laying facilities.
- Demonstrate efficiency of a PM impaction system, and other emission controls, in a high-rise laying Barn.
- Demonstrate PM and ammonia emissions from a new variety of hens fed a new diet.

1.3.2 Project Description

A bench scale test of the enzyme-based manure additive will be conducted in the Purdue Manure Reaction Laboratory to determine its effect on ammonia release from the manure. Laying hen manure collected from a layer barn will be added to eight (8) vertical cylindrical reactors at regular intervals during a thirty-eight (38) day trial. The product will be applied to four reactors according to the manufacturer's dosage instructions. The reactors will be held at 20°C and ventilated with 7 L/min of fresh air to simulate winter ventilation rates (about six air changes per hour). Ammonia concentrations in the exhaust will be measured automatically.

A new variety of chickens is believed to generate less PM emissions. Before June 15, 2004, a test will be conducted over a five (5) day period at a belt battery barn (barn 45, site 4, Croton, OH) to determine emissions of filterable particulate from the new chicken variety. A Graseby-Anderson Auto 5 sampling train will be used by Purdue University to conduct the test for comparison with preliminary tests[2] conducted in September, 2003. The emissions from one representative fan will be measured using a 3.7-m long 1.22-m dia. temporary horizontal discharge duct attached to the fan housing. On each day of the test program, three one-hour tests will be conducted, one in the morning, one in the early afternoon and one in the evening after lights are out.

The Particulate Impaction System will be tested for seven (7) days at a continuous sidewall fan (fan 13) in a laying barn (barn 2) at the Mt. Victory laying facility to determine its efficacy in controlling emissions of PM and PM-10. Measurements will be conducted with a real-time PM10 monitor and a gravimetric TSP sampler located upstream and downstream of the Particulate Impaction System. The fan will be operated continuously and measurements shall be conducted such that any difference between inlet and outlet PM concentrations will be quantitatively determined to derive the PM control efficiency of the Particulate Impaction System.

For six (6) months beginning August 1, 2004, continuous emission measurements will be conducted. The descriptions of the production barns and the monitoring plans for each site are described in Appendix A. Two (2) instrument shelters (IS) will be used to collect air emissions from a total of three (3) mechanically-ventilated layer Barns. Each IS, stationed next to one barn or between two barns, will house a gas sampling system (GSS), gas analyzers, environmental instrumentation, a computer, a data acquisition system, control units for TEOMs (tapered element oscillating microbalances), calibration gas cylinders, and supplies needed for the study. Air emissions will be measured directly at the barn exhaust. Each lab will continuously monitor the concentrations of NH_3, CO_2 and PM_{10} in the exhaust fans and in the ambient air and barn airflow. Total suspended particulate (TSP) will be measured periodically. Ammonia, PM_{10}, and TSP emission rates will be calculated by multiplying concentration differences between ambient and exhaust air by barn airflow rates. Emission rate will be calculated every minute.

1.4 Quality Objectives and Criteria for Measurement Data

The overall data quality objective (DQO) of this research is to generate data of sufficient quality to satisfy the objectives of the project. Data will undergo quality assurance review, which will assess, among other things, representativeness, completeness, comparability, and accuracy.

Data representativeness is a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point or for a process condition or environmental condition (USEPA. 1998. *EPA Guidance for Quality Assurance Project Plans*. EPA QA/G-5). Recent studies have shown that seasonal variation of gas and dust concentrations and emissions in confined animal buildings (CAB) are significant. In order to obtain measurement data that has sufficient representativeness and to fully understand the effect of season on air quality, measurement should cover the full temperature range during the year. Data representativeness will be assured by high frequency sampling and a 6-month measurement period.

Variable and multiple ventilation exhaust air streams and potential significant background concentrations at CAB present a challenge to the selection of locations for measuring pollutant concentrations that will adequately represent the mean concentration of the total barn exhaust. Data representativeness will be assured by careful selection of barns, by choosing six to seven exhaust locations instead of only one location, and by measuring concentrations at the ventilation inlet. The allocation of the exhaust measurement points for optimal representativeness must be conducted on a site-by-site basis because of

[2] MACTEC. 2003. Particulate Emissions Evaluation, Filterable Particulate, and Particle Size Testing at Layer House Ventilation Discharges at Croton Layer Sites 2 and 4. Report prepared for Buckeye Egg Farm, L.P. by MACTEC Federal Programs, Inc., 7209 E. Kemper Road, Cincinatti, OH 45249-1030.

wide variations in barn layouts and configurations (see site monitoring plans in the Appendices). Criteria for selecting fans for exhaust measurement locations are as follows:

1. The operation time of selected fan shall be equal to or greater than that of any nonselected fan in the barn. For example, continuously operated fans should be selected before any noncontinuous fan.
2. The locations of measured fans should minimize the maximum distances between unmeasured fans to the nearest measured fan.

Data completeness is a measure of the amount of valid data obtained from a measurement system, expressed as a percentage of the number of valid measurements that should have been collected (*i.e.*, measurements that were planned to be collected) (USEPA. 1998. *EPA Guidance for Quality Assurance Project Plans*. EPA QA/G-5). Data completeness will be achieved by assuring that valid data obtained from the measurement system will be no less than 75% of the scheduled sampling. More data will be collected if this criteria has not been met, by continuing data collection until 4.5 months of data have been collected. A greater percentage does not seem reasonable with potential lightning strikes, equipment breakdowns, university schedules, farm related problems, and limited budget for additional makeup monitoring.

Data completeness will be assured by: 1) properly maintained and reliable instrumentation, 2) maintaining ready supply of spare parts, 3) installing electrical backups, e.g. uninterruptible power supplies, 4) regular calibration checks, 5) frequent remote access to DAQ computer, and 6) producer collaboration and cooperation.

Data comparability will be maintained by: 1) employing similar analytical methods and sampling protocol used in recent emission studies in confined livestock facilities, 2) comparison of measurements with previous mass balance and emissions rate estimates reported for layer barns, 3) comparison of measured results with a mass balance of N at the test barns, and 4) using common equipment and protocol among the three layer barns.

Accuracy is a two-part quality indicator and includes both bias (systematic error) and precision (random error). **Accuracy** as bias or systematic error is a measure of the closeness of an individual measurement or the average of a number of measurements to the true value (EPA QA/G5). Accuracy of the measured value will be expressed in terms of the percentage decrease or increase from the known value and in terms of the absolute difference between the measured and known value. **Precision** is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions (same source). Precision is defined as the standard deviation of replicate measurements of the known pollutant gas expressed as a percentage difference from the known value. Accuracy (bias and precision) will be maintained by regular calibration of instruments involving challenging the measurement system to perform replicate analyses of samples with known concentrations (see Section 2.7).

Failure to achieve any of the acceptance criteria (Table 2) will trigger an immediate examination of sampling and/or analytical practices in order to correct the problem. Data collected under these conditions will be invalid.

1.5 Special Training/Certification

Field measurement personnel will have demonstrated training and experience through university or industry-equivalent training. This will be accomplished through face-to-face meetings and training sessions of the research team members with related expertise. A set of SOPs that will serve as a basis for this training will be maintained by Al Heber and the Purdue Agricultural Air Quality Lab for the duration of this project and will be available at each IS. The OSU research associate Dr. Harrison Sun will spend one week in June

2004 at Purdue University training to undertake testing at these facilities. He will be trained at an IS where emissions are being measured at a laying facility in Indiana.

1.6 Documents and Records

Researchers will maintain manual entry field logs including, but not limited to, site drawings, daily notes about the monitoring operation and the production buildings, results of field quality control measures, and any deviations from this QAPP. Every sample collected for off-site analysis will be documented in the field log book. Sample specific information including sample collector, time, weather data, and other relevant parameters will be recorded. In addition, chain of custody forms will be maintained for all samples analyzed off site. These field logs will be kept in a centralized location in the field laboratory. Corrections to accountable documents will be made by crossing out the error with a single line and initialing and dating the correction. A third party witness will sign and date all log notes.

The collaborating producer will keep record of mortalities, bird inventories, weight, egg production, water and nutrient consumption, and the occurrence of special activities, e.g., generator tests, manure removals or agitation, changes in diet and bird health, temperature set points, ventilation interventions, barn cleaning, power failures, etc.

Records from this project will be retained for a period of not less than two (2) years from the termination of the Consent Decree.

2 Data Generation and Acquisition

The following subsections describe the specific methods to be used to generate and acquire data. The first subsection describes the experimental design of the project. The other subsections describe sampling methods, analytical methods, sample handling procedures, and data management.

2.1 Experimental Design

The basis for the experimental design of most of the project is continuous measurements of gas and PM concentrations, and barn ventilation rates. The rest of the project includes manure additive tests, a Method test and a field test of a temporary particulate impaction curtain.

2.1.1 Gas Sampling

Using the gas sampling system (SOP 2) for the long-term monitoring, gas will be sampled from multiple exhaust air locations, and ambient air (Figures B1 and C1). Gas sampling location groups (SLG) consist of one or more multiple tubes that bring air into a mixing manifold from multiple sampling points. For example, an SLG could consist of two or three tubes that bring air into a mixing manifold from representative sampling points. However, in this project, all SLGs will consist of only one sampling point.

At least four emission points are necessary for a large barn with 20 to 50 fans or in a barn with four or more fans running on stage 1, or a barn with four minimum winter variable speed fans. There is spatial variation between the emission exhaust points, thus the objective is to eliminate bias in the measurement of exhaust air concentration. Since there are multiple exhaust points from a barn, it is not advisable to use the concentration measured at one fan and the airflow of another fan to calculate emission rate of both fans if the fans are separated by a large distance or if one is in the pit and the other is in the wall. If the fans are grouped together, e.g. tunnel ventilation, a single point may be representative of air exhausting from each fan. In laying barns with many uniformly distributed fans along each sidewall, it is important to sample at uniformly distributed multiple sampling points along each sidewall. In this project, 6 or 7 exhaust fans will be monitored from each barn or 12 to 15% of the total fan inventory.

Air from each location will be sampled and measured continuously for 10 minutes before switching to the next location. Thus, for 12 locations, a 120-min sampling cycle will be applied with a 10-minute sampling period resulting in 12 sampling periods per day per location, Table 1. The first few minutes of gas concentration data will be ignored to allow all gas analyzer outputs to stabilize. To ascertain that a certain purge period will achieve a 90% minimum response to a step input, the response time of the system will be initially tested by attaching a 50-L bag of calibration gas at the end of the longest sampling tube. If the equilibrium time of a particular gas analyzer, e.g. NH_3, is shorter, then less data from that analyzer will be ignored, e.g. perhaps only the first 2 or 3 minutes of each sampling period. If equilibrium time is longer than 10 minutes, the sampling period will be increased.

Ambient air will be sampled twice daily or every 12 hours with a sampling period of 30 minutes. A longer sampling period is used with ambient air because of the time required for ammonia to desorb from tubing and other surfaces in the gas sampling system.

Hourly sampling of each location is assumed to be sufficient to capture the variations in emissions, especially when there are two to seven exhaust locations in each barn. With six exhaust locations or SLGs per barn, the pollutant concentrations in exhaust air will be measured 72 times daily per barn.

The duration of samples at a given location can be calculated as the total number of samples times the number of readings per sample or 12 x 3 minutes = 36 minutes or 2.5% of the day. Although this seems like a small percentage of the time, it is the frequency of sampling compared to the frequency of the measured variable that is important, not the total duration of sampling. The 24, one-minute samples are distributed throughout the day, thus capturing the diurnal variations of emissions.

2.1.2 Gas Concentration Sampling and Measurement

Ammonia

Ammonia will be measured in real time with a chemiluminescence (CL)-based NH_3 analyzer (Model 17C, Thermal Environmental Instruments (TEI), Franklin, MA), which is a combination NH_3 converter and a NOx analyzer that is typically used for ambient monitoring but has a range capable of measuring typical concentrations inside barns. Sample air is drawn at a flow rate of 0.6 L/min from the converter into the NH_3 analyzer through a particulate filter, a glass capillary, and a solenoid valve. The solenoid valve routes the sample either directly into the reaction chamber (NO mode) or through the converter and the reaction chamber (NO_x mode). NH_3 concentration is calculated based on the difference between these readings. The 0 to 90% response time is 120 s with 10 s averaging. Besides having an appropriate range for source measurements, the CL method is known for its stability, reliability, and high precision (0.5% of full scale). The full scale will be 1-100 ppm, depending on maximum expected levels. If NO and NO_2 measurements are negligible, the analyzer will be operated in the total N mode to decrease response time and costs of NH_3 scrubbers (Heber et al., 2002a).

A photoacoustic infrared (PIR) ammonia monitor (1,000 ppm) (Mine Safety Appliances, Pittsburgh, PA) will be collocated with the CL method for the barn measurements. Each ammonia analyzer will be calibrated at least two times per week using standard gases. The standard gases will first be checked using an FTIR gas spectrometer at Purdue University to verify their accuracy.

Carbon dioxide

Concentrations of CO_2 will be measured using a 10,000-ppm photoacoustic infrared CO_2 analyzer (Model 3600, Mine Safety Appliances, Co., Pittsburgh, PA). The sensor utilizes dual frequency photoacoustic infrared absorption and is corrected for water vapor content. The guaranteed accuracy of this analyzer is ±2% of full scale and the sample flow rate is about 1.0 L/min (MSA *Model 3600 NEMA 4X Infrared Gas Monitor Instruction Manual*).

2.1.3 Particulate Matter

2.1.3.1 PM_{10} Sampling

The PM_{10} (10 μm particles and smaller) will be monitored with the TEOM (Tapered Element Oscillating Microbalance), which is a continuous PM monitoring device, that with the appropriate inlet, is designated by USEPA as an equivalent method for PM_{10} (EPA Designation No. EQPM-1090-079). The sample stream temperature shall be 50°. The TEOMs will be adjusted to report data at one atmosphere and 20°C. See SOP 6 for more details on the description, operation, calibration and maintenance of the TEOM.

PM_{10} will be sampled continuously with the TEOM at one minimum winter ventilation fan in each barn, side by side with an exhaust gas sampling point. The sampling location will be inside the barn near the inlet of the fan, however, far enough away to avoid concerns about anisokinetic sampling. The air velocity around the sampling head should be 400 fpm (2 m/s) or less. This corresponds to the minimum air velocity in a tunnel ventilated barn in the summer. The calculated Stokes number for the inlet will be less than 0.01 to validate isokineticity.

2.1.3.2 Total Suspended Particulate

The concentration of total suspended particulate (TSP) at the inlets of the exhaust fans will be determined gravimetrically using a multipoint sampler that draws 20 L/min through each 37-mm glass fiber filter (loaded in 2-piece open face filter holder) using a critical venturi method. Filters will be replaced twice weekly with sampling periods of one to two days, depending on measured concentrations. The filters will be located at three different heights within the fan inlet (less than 0.5 m from the fan impellers). The filter holders will be fitted with an isokinetic sampling head and pointed into the exhaust air leaving the barns. The calculated Stokes number for the inlet will be less than 0.01 to validate isokinetic conditions.

2.1.4 Temperature and Relative Humidity Measurement

Ambient temperature will be logged for purposes of calculating the mean daily temperature for comparison with historical records and if possible, analysis of ambient temperature effects on emission rates. The temperature and humidity of exhaust air along with barometric pressure is needed for accurate volume correction to standard conditions. A total of sixteen (16) copper-constantan thermocouples (Type T) will be used to sense temperatures throughout the barns and in the trailer at the following locations: 1) heated raceways, 2) trailer and instrumentation, 3) ambient air, and 4) exhaust sampling points. The thermocouples will be used with a 16-bit thermocouple module (FP-TC-120, National Instruments, Austin, TX). The sensors will be calibrated prior to and following each six-month monitoring period using a constant-temperature bath.

An electronic RH/temp transmitter (Model HMW61, Vaisala, Woburn, MA) housed in a NEMA 4 enclosure will monitor temperature and relative humidity at a representative exhaust location in each barn. An electronic RH/temp transmitter with a passive solar radiation shield (Model HMD60YO, Vaisala, Woburn, MA) will be used to measure temperature and relative humidity at a representative outdoor location between the barns. Both RH/temp transmitters (Models HMW61 and HMD60YO) use a HUMICAP sensor unit with ±2% accuracy between 0 and 90% RH and ±3% accuracy between 90 and 100% RH.

2.1.5 Pressure Measurement

Barn static pressure will be monitored continuously in the barns near the exhaust fans using a differential pressure transmitter (Setra Part No. 2671-100-L-B-11-9K-F-N) with a range of ±100 Pa and an accuracy of ±0.5 Pa. The purpose of differential pressure measurements is to monitor operation of the ventilation system and to aid in the calculation of fan airflow. The pressure sensor will be shunted to calibrate zero and compared with an inclined manometer at various span pressures. Static pressure taps will be constructed to minimize effects of air movement from wind on the measurement. Atmospheric pressure will be monitored with a barometric pressure transducer in the TEOM.

2.1.6 Ventilation Fan Monitoring

The status of exhaust fan operations will be monitored via auxiliary contacts of the fan motor relays at the barn environmental control panel, vibration sensors attached to each fan housing, and small vane anemometers installed at the fans with gas sampling probes. A mean of sixty 1.0-Hz readings will be recorded per minute of each variable.

Actual fan performances are typically 5 to 20% less than published fan curves due to dust buildup, belt wear, and shutter degradation and emissions are overestimated unless fan deratings are known. A FANS (fan assessment numeration system) (Becker, 1999), a calibrated anemometer system with multiple traversing impellers, will be used to spot measure actual fan airflow capacities in the field after first calibrating the FANS (with each fan model removed temporarily from the barns) at the University of Illinois BESS Lab. The BESS lab can measure fan capacity with an accuracy of ±2% using a standard method (AMCA, 1985). In this way, the FANS will serve as a field-based reference measurement technique. The spot measurements will be conducted between July and September and will consist of at least three replications per fan each time.

A bi-directional small vane anemometer (SVA) (much smaller in diameter than fan diameter) will also be calibrated to the fans at the UIUC BESS lab and mounted on gas-sampled fans in the field to monitor airflow rate continuously. The advantage of the SVA is that the significant effects of wind and barn static pressure are accounted for with the technique. The SVAs will be calibrated during the BESS tests and the in-field tests with the FANS. The barn ventilation rates will be determined by monitoring the operation of all fans (using dry contacts on relays or vibration sensors along with the SVA on representative fans) and the barn static pressure and determining the fan airflow from the actual fan performance curves. The accuracy in measuring daily mean barn airflow in this way is estimated to be ±10%.

Wind speed and direction will also be monitored continuously with a wind direction vane and a cup anemometer located on a 1 to 1.5 m high tripod that straddles the ridge of the adjacent barn at a location nearest the instrument shelter. Wind information will be used to correlate with and confirm wind induced static pressure influences on fan airflow. It is important during data analysis to explain anomalies in fan airflows during high winds and low gas concentrations due to back drafting.

2.1.7 Emission Calculation

The following is an example calculation of ammonia emission from the measured data. The example converts a measurement of 1 ppm into an emission rate. The first line is a conversion to mass concentration, using a sample point temperature of 20°C. The second line is the conversion from mass concentration to emission.

$$1 \text{ ppm NH3} = \frac{1\text{ m}^3\text{ NH}_3}{10^6\text{ m}^3\text{ air}} * \frac{17\text{g NH}_3}{\frac{22.4\text{L NH}_3 * (273\text{K}+20^\circ\text{C})}{273\text{K}}} * \frac{10^3\text{ L NH}_3}{1\text{ m}^3\text{ NH}_3} * \frac{10^6\text{ ug NH}_3}{1\text{ g NH}_3} = 706.68\ \frac{\text{ug}}{\text{m}^3} @\ 20^\circ\text{ C}$$

$$706.68\frac{\cancel{\text{ug}}}{\cancel{\text{m}^3}} * \frac{1\text{ kg}}{10^9\ \cancel{\text{ug}}} * \text{airflow} @\ 20^\circ\text{ C}\ \frac{\cancel{\text{m}^3}}{\cancel{\text{s}}} * 86400\ \frac{\cancel{\text{s}}}{\text{day}} = \text{airflow} @\ 20^\circ\text{ C} * 0.06105\ \frac{\text{kg}}{\text{day}}$$

where airflow is the actual airflow in cubic meters per second.

For other temperatures, replace 20 C with the actual sample point temperature. To generalize this equation, substitute 20°C with T where T is the actual sample point temperature.

Airflow rates and concentrations will be corrected to dry standard conditions for reporting.

2.2 Sampling Methods

Sampling methods are covered in SOP 2 (Gas Sampling), 16 (TSP Sampling), 18 (Manure Sampling) and Appendices A-C.

2.2.1. Manure Analysis

The layer barns will be sampled monthly to determine moisture content, which is an important factor affecting PM emissions. Thirty-six (36) surface samples will be collected from randomly selected locations in each deep pit barn and sixteen (16) locations in the belt battery barn. Each sample will be put on ice and delivered to a manure analysis laboratory for analysis of moisture content.

2.3 Sample Handling and Custody

Filters used for all PM sampling will be visually inspected for contamination and defects prior to using them. After sampling, the filters will be removed from their holders and will be visually inspected prior to delivery to the lab. Considerable care will be taken when removing the filter from the holder to ensure fibers are not lost. The filters will be desiccated for at least 24 hours prior to pre- and post-weighing, and weighed using standard protocol for gravimetric analysis.

Filtered particulate and manure samples, Table 1, will be labeled and logged on standard field data sheets (see SOPs) at the time of placing and collecting the samples and also logged into the field log book. The samples will then be transferred directly to the laboratory for evaluation. Information on the particulate filter data sheets includes date, time of day, personnel, sampling location, airflow rate, sampling start time, sampling stop time, temperature, any unusual conditions or observations, weight of pre-sampling, weight of post-sampling, and particulate matter (PM) concentration. Information on the sample data sheets includes date, time of day, personnel, sampling location, sampling start time, sampling stop time, temperature, and any unusual conditions or observations. All field data will be recorded and checked for completeness and accuracy before leaving the site. Laboratory data sheets will be prepared and signed as samples are processed. Chain of custody will be documented with signatures of those who relinquish and receive the samples.

2.4 Analytical Methods

Analytical methods are covered in SOPs 3, 5, 6, 7 9, 10, 11, 16, 19, and 21.

2.5 Quality Control Measures

Quality assurance and quality control includes the use of properly maintained and reliable instrumentation, approved analytical methodologies and standard operating procedures, external validation of data, well-trained analysts, electrical backups, audits, and documentation. When appropriate, published EPA analytical methodologies will be used. The procedures contained in the "Quality Assurance Handbook for Air Pollution Methods," EPA 600/R-94/038C will serve as the basis for performance of all testing and related work activities. Logs will be maintained for each instrument.

Specific quality control procedures will include the following:

- A replicated multipoint calibration of analyzers will be performed initially and whenever the zero and span checks are beyond acceptable limits. The acceptable limits for differences in span (drift) are ±20% of full scale for the chemiluminescence analyzer, ±10% for the photoacoustic infrared ammonia analyzer and ±5% for carbon dioxide. The acceptable limits for differences in zero offset is 1% of full scale for each analyzer. These are based on the behavior of these analyzers observed in previous studies at Purdue University. Calibration checks (zero and span) of gas analyzers will be conducted weekly. Electronic calibration records will be maintained in the data acquisition PC, saved in network drives at Purdue University, and printed with hard copies placed in a field loose leaf notebook.
- The TEOM PM10 monitors will be compared with FRM method PM10 samplers operated alongside. This will be done once in summer and once in winter. A consistent relationship between the two methods should be determined.
- Thermocouples will be calibrated before and after test periods with spot checks of each sensor every three months.
- Temperature and relative humidity sensors will be verified with a NIST transfer standard (Vaisala Model HMP46).
- Calibrations of the differential pressure transmitters will be conducted before and after the test. Zero checks will be conducted monthly.
- The data acquisition PC will be connected to the internet. Real-time measurements of continuously measured variables will be accessible over the internet via PCAnywhere™. Research personnel will check the on-line display at least daily by either remote or on-site access.
- Logged data files in the PC in the previous day will be checked the next business day to find and correct any problems with the system. This responsibility will be shared among Drs. Zhao, Sun, Heber, Ni and Lim but will be done by at least one person each day, who will sign the data file electronically. Corrections will be signed off in electronic notes.
- Analysts will be properly trained to operate all equipment and properly implement QAQC procedures.
- Internal performance and system audits will be performed in August and November 2004 for the continuous barn air emission measurements.
- An uninterruptible power supply with battery backup will be used to prevent damage to sensitive equipment and data loss in case of power failure. Furthermore, a lightning arrestor will protect the entire on-farm instrument shelter and secondary surge suppressors will protect the PC and the instruments. Also, lightning rods will be installed on the met towers and on the trailers.
- Leak tests will be regularly performed on the multipoint gas sampling systems every week, on the TEOMs and gas sampling probes every month, and on the Method 17 stack sampling system before and after each test run.

- The pressure and flow rate of the probe manifold will be monitored to aid in diagnosis and troubleshooting the gas sampling system.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

All analytical equipment will be properly maintained and tested regularly to ensure they are functioning properly in accordance with the manufacturer's recommended intervals and acceptance parameters. Equipment, including meteorological equipment, sampling pumps and analytical equipment will be inspected regularly during each sampling event. Equipment will be repaired as soon as possible upon discovery of a problem. Manufacturer's instructions for routine maintenance of equipment will be followed. All testing, inspection and maintenance activities will be documented in the field project log book.

2.7 Instrument/Equipment Calibration and Frequency

Initially, a multipoint calibration of the analyzers will be conducted in triplicate using either a precision gas mixing and dynamic dilution system with a span gas and zero air or multiple cylinders of calibration gases that provide a series of concentrations that spans the range of expected concentrations for the target analyze. Accuracy and precision of the analyzers will be determined from these measurements. The maximum gas concentration selected for the multipoint calibrations will be between 70 and 200% of the expected emission levels. Routine calibration checks will be conducted weekly by introducing a span gas into manifold M2. In this way, the calibration gas will flow through the same plumbing that the samples flow through in the trailer except for the 3-way solenoids. A computer-controlled calibration system (at some universities) will allow consistent calibration thus eliminating human error. Bimonthly, a bag of calibration span gas and a bag of zero gas will be manually introduced into the filtered end of a sampling tube.

Certifications for calibration gases will be according to EPA protocol, where available for a given concentration. The certified calibration gases will consist of zero air (Acid Rain CEM zero), NO in nitrogen (EPA Protocol, ±2% accuracy), NH_3 in nitrogen (Title 5 ammonia per EPA Conditional Method 27E, ±3% accuracy), and CO_2 in N_2 with 2.5% methane (EPA Protocol, ±1% accuracy). Regulators for calibration gas cylinders will be dual-valve with stainless steel diaphragms.

The NH_3 analyzer will be challenged with zero air, a NH_3 span gas (dual-certified by NIST-traceable gravimetric formulation and analysis based on vendor reference standard), and a NIST-traceable NO span gas. The NH_3 calibration will be conducted weekly whereas the NO calibration will be conducted initially and every 1 to 3 months as a maintenance check to calculate converter efficiency. The CO_2 analyzer will be challenged with zero air and a known concentration of NIST-traceable CO_2 span gas.

The filter weighing microbalance of the TEOM will be calibrated with a NIST-traceable preweighed filter prior to the study, every 3 months, and after the study is completed. TEOM airflows will be calibrated using precision airflow calibrators (Gilian Airflow Calibrators for 0.02-6.0 L/min and 2-30 L/min flow rates). Airflow calibration will be conducted each time the filter is changed. The TEOM will be operated at 50°C.

Thermocouples will be calibrated prior to commencing the study, and every three months thereafter. A water bath and two precision ASTM mercury-in-glass thermometers (-8 to 32°C and 25 to 55°C, 0.1 °C precision) will be used for calibration. A salt calibrator kit (Model HMK1520000A01000, Vaisala, Woburn, MA) will be used to calibrate the capacitance-type rh/temp sensors prior to commencing the study, and every three months thereafter. Though unbudgeted for this project, a portable RH/temp probe (Model HMP46, Vaisala, Woburn, MA) with an indicator (Model HM141, Vaisala, Woburn, MA) can optionally be used as a NIST-transfer device to check the RH/temp transmitters and the thermocouples every three months.

The differential pressure transmitters will be calibrated prior to use and recalibrated at the conclusion of the test at 0 and typical barn static pressure of 20-40 Pa by direct comparison with an inclined manometer. The zero will be checked monthly.

The electronic barometric in the TEOM unit will be calibrated against a mercury barometer or the nearest weather station.

Calibration records of gas analyzers, PM_{10} monitors, temperature sensors, and pressure transmitters will be maintained in accordance with applicable standard operating procedures.

2.8 Inspection/Acceptance of Supplies and Consumables

All atmospheric gaseous measurements will be traceable to dual-analyzed and certified standards from a reputable supplier (Matheson Gas, Joliet, Ill). The NH_3 span gas will be dual-certified by NIST-traceable gravimetric formulation and analysis based on vendor reference standard. Supplies will be inspected immediately upon receipt, and returned to the vendor if found to be unusable. A supply of spare parts in working condition will be maintained whenever possible in order to ensure continuous data collection.

2.9 Data Acquisition Requirements (Non-Direct Measurement)

2.9.1 Not applicable.

2.10 Data Management

All original and final data will be reviewed and/or validated by technically qualified staff, and so documented in the program records. The documentation will include the dates the work was performed, the name of the reviewer(s), and the items reviewed or validated.

Corrections and additions to original data must be made as follows:

- After correction, original entries must remain legible (for manual corrections) or intact (for computerized corrections).
- The correction or addition must be readily traceable to the date and staff who performed the correction or addition.
- Corrections must be explained.

Electronic raw data and computer records will be backed-up weekly on a network drive (backed up daily). If connected to the internet, data will be automatically emailed by Labview to other computers. In addition to computer storage, raw tables or graphs will be printed out and stored in a loose-leaf notebook in the various campus laboratories.

Field test documentation and electronic data storage will be maintained in accordance with standard operating procedures, Table 3, (see Appendices for complete SOPs) including storage of all raw electronic data in ASCII file format for later analysis using commercially-available spreadsheet and statistical programs (SOP 20 Data Management). A large portion of the data will also be maintained electronically in the form of spreadsheets. All NH_3, CO_2, PM, temperature, pressure, relative humidity and wind speed and direction data will be electronically stored and compiled in a manner that will facilitate computation of hourly and daily averages.

Reports will be prepared by qualified staff only from properly reviewed and validated data. All data will be reported in units consistent with other measurements. Assumptions will be clearly explained as to validity and limitations.

Accurate working files of all documentation, including logbook entries, original data, calculations, deviations from approved procedures, data uncertainties, assumptions, QA/QC results and external performance data, audits, and review, inspection, and validation will be maintained by the respective State's principal investigator as appropriate. Project records will be maintained in a systematic and logical form and adequately filed for rapid retrieval, accounted for and appropriately indexed.

3 Assessment and Oversight

The following subsections describe assessment and oversight measures to be taken during data collection. These actions are separate from the final data validation described in Section 4.

3.1 Assessments and Response Actions

The Dr. Heber and his staff with assistance from Drs. Zhao and Sun at Ohio State University will be responsible for routine assessment and internal QAQC audits of data collection, evaluation of data in accordance with validation procedures, and for initiating necessary response actions. The routine assessment will include review of data to ensure that instruments are functioning and collecting information. The PI will assess the data for representativeness, completeness, comparability, accuracy and precision as outlined in Section 4. Routine assessment actions will also include review of the QC measures described in Section 3. Response actions will be initiated immediately upon discovery of a problem. The PI will perform these response actions as needed to collect data that meet the project DQOs.

The Project QA Manager (Dr. Heber), will conduct at least one external field oversight of sampling and analysis activities at each site, during which performance audit samples will be analyzed (Section 3). During field oversight, the Project QA Manager will visually observe sample collection and analysis to verify that the procedures outlined in this QAPP are being followed and that any corrective action initiated previously is being continued. Field documentation of samples, calibration, QC measures, and corrective action will also be reviewed. In addition, the Project QA Manager will conduct a review of data and record management systems during the field monitoring period. During this review, the Project QA Manager will verify that the data management procedures (Section 3) are being followed. Any issues identified during these reviews will be discussed with appropriate personnel and addressed immediately.

3.2 Reports to Management

During project data collection, Dr. Heber and his staff with assistance from Drs. Zhao and Sun at Ohio State University will be responsible for routine assessment and response actions as described above. If response actions are taken, the PI will inform the Project QA Manager of the reason for these actions and the results. The Project QA Manager will then review this information to verify that the QAPP is being followed and to determine if changes to the QAPP are needed. If conditions requiring corrective action are identified during a review conducted by the Project QA Manager, a brief report will be issued by the Project QA Manager to the Project Manager and the PI; however, corrective action will be initiated immediately based on verbal discussion during the review.

The final project report will contain all valid monitoring data expressed as hourly and daily values. The report will incorporate graphical representations of the location of all measurements taken. The report will also contain the numerical and qualitative results of all QC measures on all measurement systems and will compare them to the applicable acceptance criteria. In the event that data must be invalidated, the reason for data invalidation shall be identified with the resultant corrective action. In addition, the report will include a brief summary of corrective actions taken during field data collection. The report will discuss the impact of these corrective actions on data quality. The final report will be distributed to the following individuals or agencies:

Kevin Vuilleumier	U.S. EPA Region 5
Cary Secrest	U.S. EPA Enforcement Division
Brian Babb	Keating, Muething & Klekamp, P.L.L.
Don Hershey	Ohio Fresh Eggs

4 Data Validation and Usability

4.1 Data Review, Verification, and Validation

All data generated under this QAPP will be reviewed and validated primarily by Purdue University (Drs. Heber, Ni and Lim) with assistance from Ohio State University (Dr. Zhao and Dr. Sun).

Original raw data review will be done within two business days after the data were recorded from measurement. Data will be evaluated for compliance with stated objectives for representativeness, precision, and accuracy. This will be done by comparing results of QC and calibration activities to the stated data quality criteria (Section 2). However, the evaluation process used to find and correct an error may not be defined in this QAPP because not all possible errors and corrections can be anticipated.

4.2 Verification and Validation Methods

Data will be validated and verified by comparison with instrumental performance parameters as identified in the applicable section of this QAPP or instrument operation manual.

Two formal supervisory audits of the continuous emission tests will be conducted by Dr. Heber, once in August and again in November. The purpose is to verify compliance of the test with this quality assurance project plan. The supervisory audit form for these audits is given in Appendix E.

The control charts showing zero and span checks with time will prove gas analyzer performance.

A minimum of ten percent of all the days of analyzed data will be reviewed by Dr. Heber for the purpose of quality control. The days to be reviewed will be randomly chosen from the data set. Dr. Heber will deliberately search for systematic and random errors in the entire process of data analysis. Dr. Heber will make final decisions on issues regarding data validity based on a thorough review of all data and evidence surrounding a nontrivial issue.

Data will be analyzed using custom software (CAPECAB "Computations of Air Pollutant Emissions from Confined Animal Buildings) developed by the RSLS Group of Companies (Calgary, Alberta) for Purdue University. As data is collected in real-time by the data acquisition computer, it will be converted to binary format and transferred automatically to a server at Purdue University. CAPECAB allows immediate access to the data to visualize and inspect the data, and facilitates data validation via interactive and automatic flagging. It performs interpolations between concentration measurements, which coupled with continuous airflow measurements, allows the creation of an emission value every minute. From this 60-s database, the program creates averages over user-specified intervals (5-minutes, 60-minutes, 24-h, weekly, etc.). Thus, the following day, CAPECAB can create a report of hourly averages for the previous day. The data will be presented in the final report in terms of daily means along with the variance of the daily means.

4.3 Reconciliation with User Requirements

Any data not meeting the DQOs as outlined above will be flagged as invalid for comparison to screening level criteria.

References

AMCA. 1985. Laboratory methods of testing fans for rating. AMCA Standard 210-85. Arlington Heights, IL: Air Movement and Control Association.

Becker, H. 1999. FANS makes measuring air movement a breeze. Agricultural Research Magazine, July [http://www.ars.usda.gov/is/AR/archive/jul99/fans0799.htm].

Heber, A.J. 2000. "Nitrogen Loss Measurements in Swine and Poultry Facilities", ADSA DISCOVER Conference on Nitrogen Losses to the Atmosphere from Livestock and Poultry Operations. Nashville, IN, April 28-May 1.

Heber, A.J., J.-Q. Ni, B.L. Haymore, R.K. Duggirala, and K.M. Keener. 2001. Air quality and emission measurement methodology at swine finishing buildings. *Transactions of ASAE* 44(6):1765–1778.

EPA. 1996. Direct Measurement of Gas Velocity and Volumetric Flow Rate under Cyclonic Flow Conditions (Propeller Anemometer). EPA Conditional Test Method. Emission Measurement Branch, EMTIC CTM-019.WPF, Technical Support Division, OAQPS,

Table 1. Sample collection and analysis.

Location	Matrix	Parameters	Interval
Ambient or background air	Air	NH_3, CO_2	12 h
Ventilation exhaust locations	Air	NH_3, CO_2	2 h
Ventilation exhaust locations	Air	PM_{10}	1 min
Ventilation exhaust locations	Air	TSP	Twice weekly
Manure pit*	Manure	N, pH, mc	Monthly

*Optional

Table 2. Data quality objectives.

Parameter	Sample Matrix	Detection Limit	Quantitation Limit	Estimated Accuracy	Estimated Precision
NH3	Air	2 ppb	200 ppm	±15%	±5%
CO2	Air	200 ppm	10,000 ppm	±15%	±5%
PM_{10}	Air	1 $\mu g/m^3$	10,000 $\mu g/m^3$	±15%	±5%
Airflow (FANS)	Air	0.05 m^3/s	12 m^3/s	±20%	±10%
Temperature	Air	-40°C	50°C	1°C	0.5°C
Relative humidity	Air	5%	95%	5%	2%
Diff. pressure	Air	-100 Pa	100 Pa	2%	0.25%
Wind speed	Air	1 m/s	60 m/s	2%	2%
Wind direction	Air	0°	360°	3°	3°

Table 3. Characteristics of test sites and barns.

Location	Mt. Victory	Croton Barn #2	Croton Barn #45
Livestock type	Laying hens	Laying hens	Laying hens
Inventory†	169,000	168,000	102,000
Average mass, kg	1.6	1.5	1.5
Animal occupation, d	602	420	420
# barns at site	14	16	16
Year of construction	1994	1982	1984
Year of remodeling	-	2004	2001
Barn type	HR	HR>Belt	HR>Belt
Number of tiers	4	7	7
Orientation	E-W	N-S	E-W
Distance to site, km	85/394	63/443	58/438
Shower in/out?	N	N	N
Barn width, m	20.7	15.85	15.85
Barn length, m	201.2	161.6	110.9/161.6*
Barn area, m^2	4,172	2,561*	1,758/2,561*
Ridge height, m	10.0	10.4	10.4
Sidewall height, m	6.5	6.4	6.4
Barn spacing, m	20.7	15.9	15.9
Basement depth, m	3.15	-	-
Manure collection	DP	Belts	Belts
Manure storage in barn, d	365	1-5	1-5
Number of pit circulation fans	18‡	-	-
External storage	none	Yes	Attached shed
Duration of external storage, d	-	365	365
Number of air inlets†	8	6	6
Inlet type	CCB	CCB	CCB
Inlet adjustment method	CT ramp	CT ramp	Cane-arm swing
Inlet control basis	Δp and T	Δp and T	Δp and T
Controls vendor	PMSI	PMSI	PMSI
Number of exhaust fans†	50	46	22
# variable speed fans	0	0	0
Largest fan dia., cm	122	122	122
Smallest fan dia., cm	122	122	122
Fan spacing, m	7.3	6.4	9.1
Fan manufacturer	AT[a]	ValAir	AT
# ventilation stages‡	26	12 (3,3,4)	11
# temperature sensors†	16	12	8
Emergency ventilation	Generator	Generator	Generator
Artificial heating	N	N	N
Summer cooling	-	-	-
Number of inlet SLG†	0.5††	1	-
Number of exhaust SLG†	6	7	1
No. emission streams	6	7	1
Gas probe lengths, m	12-115	12-115	-
Internet service type	TBD	TBD	-
Start date in 2004	August 1	August 1	June 1

*including the manure storage section, †per barn or room

††one sampling probe located between the barns represents inlet air for both barns

‡Number of drying fans will be increased to 40 by December, 2004.

[a]Modified with some CT parts.

AE:Automated Environments, AT:Aerotech, CT:Choretime, DP:deep pit, EP:evaporative pad, HR:high rise,PMSI=Poultry Management Systems, Inc.

Abbreviations and Acronyms

BESS	Bioenvironmental Systems and Simulations Lab at the University of Illinois
CAB	Confined animal buildings
CCB	Center-ceiling baffled inlet
CEM	Continuous emission monitoring
DAQ	Data acquisition
DQO	Data quality objective
EP	Evaporative pad
FRM	Federal reference method
GSS	Gas sampling system
MC	Moisture content
MV	Mechanically ventilated
PEF	Grade of Teflon
PFA	Grade of Teflon
PI	Principle Investigator
PM	Particulate Matter
PM10	Particulate Matter less than 10 μm diameter
PREF	Primary representative exhaust fan
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
SLG	Sampling location group
SOP	Standard Operating Procedure
RH	Relative humidity
TEOM	Tapered element oscillating microbalance
TSP	Total suspended particulate

Chemical Names

CO_2	Carbon Dioxide
NH_3	Ammonia

Appendix A: Method 17 Tests of Particulate Matter Emissions

The purpose of the Method 17 test will be to determine the effect of a new variety of chickens and feed in reducing particulate matter emissions. The results of the test will be compared with an identical Method 17 test conducted in 2003 at a barn with old varieties of chickens and feed (MACTEC, 2003). A regression analysis for temperature effects will be used to normalize the emission rate data for both the previous test (MACTEC, 2003) and this test. The test will be conducted in such a manner as to produce comparable data.

Description of the Laying Barn

PM emissions will be measured from a caged-hen laying barn (Barn #45, Site 4) at the Croton Facility (11492 Westley Chapel Rd, Croton, OH 43013), Figures A1 and A2. The facility was constructed in 1984 and the barn was remodeled in 2001. The remodeled barn has a belt battery manure removal conveyor system and is oriented E-W, Figure A2. The barn is 161.6 m x 15.85 m and will house 102,000 hens in six rows of 7-tier cages, which were installed when the barn was converted from the conventional two-story high rise to a belt battery barn with the cages occupying both floors. Water is provided through drinking nipples and feed is delivered by chains and feed troughs. The cage bottoms are sloped for eggs to roll onto egg collection belts. All ventilation fans are located in the lower level. Manure will be collected on plastic belts under the cages and removed from the barn in 1 to 5 days, since the belt travels 20% of the total distance every day and makes a full circle through the barn every five days. Air is blown on the belt to reduce manure moisture content. Ventilation air enters the second floor from the attic through temperature and pressure-adjusted baffled ceiling air inlets over each row of cages. There are 11, 48-in. (122-mm) dia. belted exhaust fans (Aerotech Model AT481Z3CP-24 with 1.0 Hp Motor #PN-B-176835-04) fans (#12-#22) distributed along the north sidewall and 11 fans (#1-#11) on the south sidewall, Figure A3. The fans are 9.1 m apart. The barn has eight temperature sensors and is ventilated in 11 stages, Table A1. Each stage consists of two fans. Eggs are removed on conveyors into the egg processing plant. The lights are shut off for several hours each night. Egg production and water and feed consumption are recorded automatically. Daily mortalities are recorded manually. The hens in barn 45 were 34 weeks old on May 1, 2004.

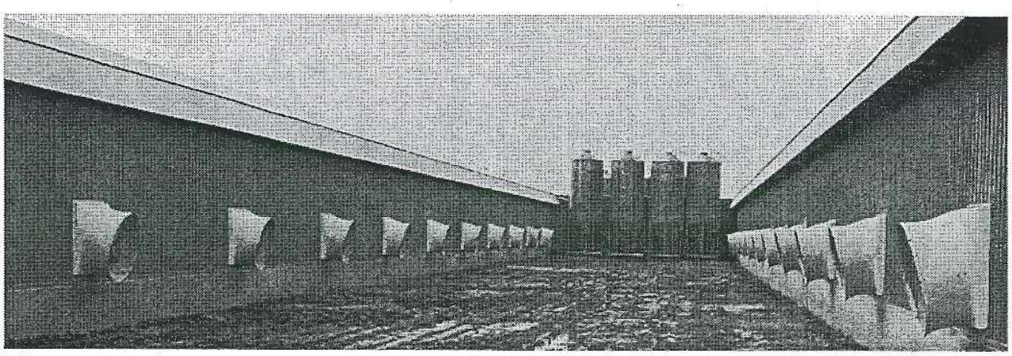


Figure A1. Croton layer facility, Site 4. Barn 45.

Site Measurement Plan

Figure A3 shows a schematic of the barn emission measurement plan. Sampling of particulate will be conducted immediately upstream of fan F8 which is defined as the primary representative exhaust fan (PREF) on Barn 45, Figure A3. Three runs will be conducted on each of five days between May 27 and June 10, 2004. On each day, three one-hour tests will be conducted, one in the morning, one in the early afternoon and one in the evening after lights are out.

Stack Sampling of Filterable Particulates

An EPA Method 5 sampling train (Graseby Auto5™, Thermo Electron, MA) modified for use with Method 17 will be used by Purdue University to measure filterable particulate emissions. The sampling and analytical methods for the filterable particulate sampling will conform to the requirements of U.S. EPA Reference Methods 1-4 and 17. A brief description of each method follows:

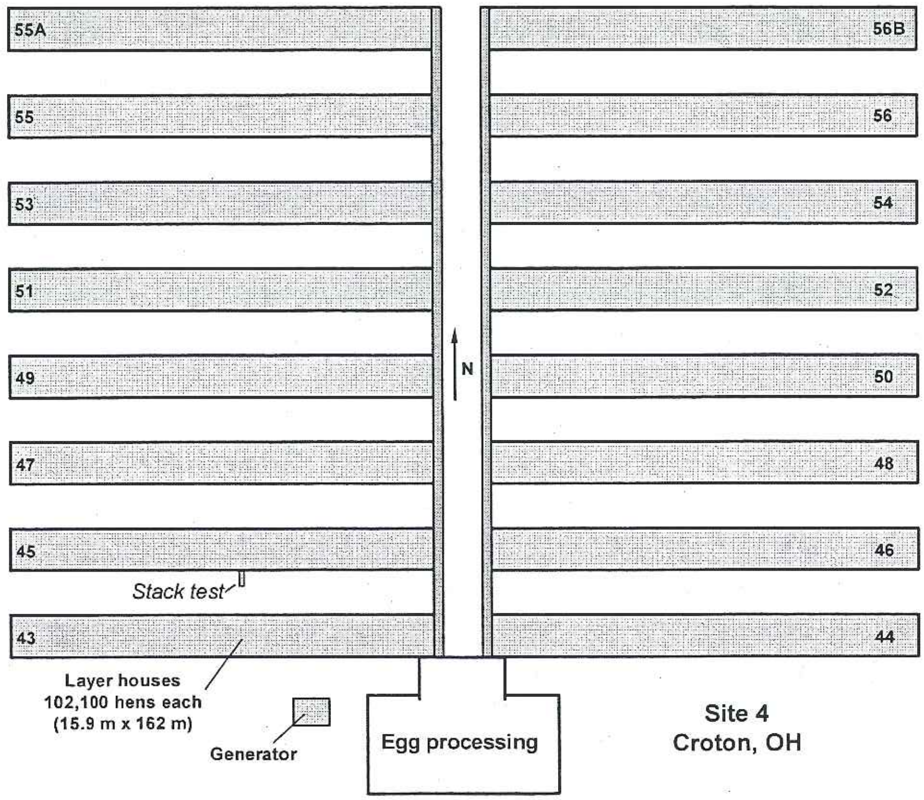


Figure A2. Layout of barns at Site 4.

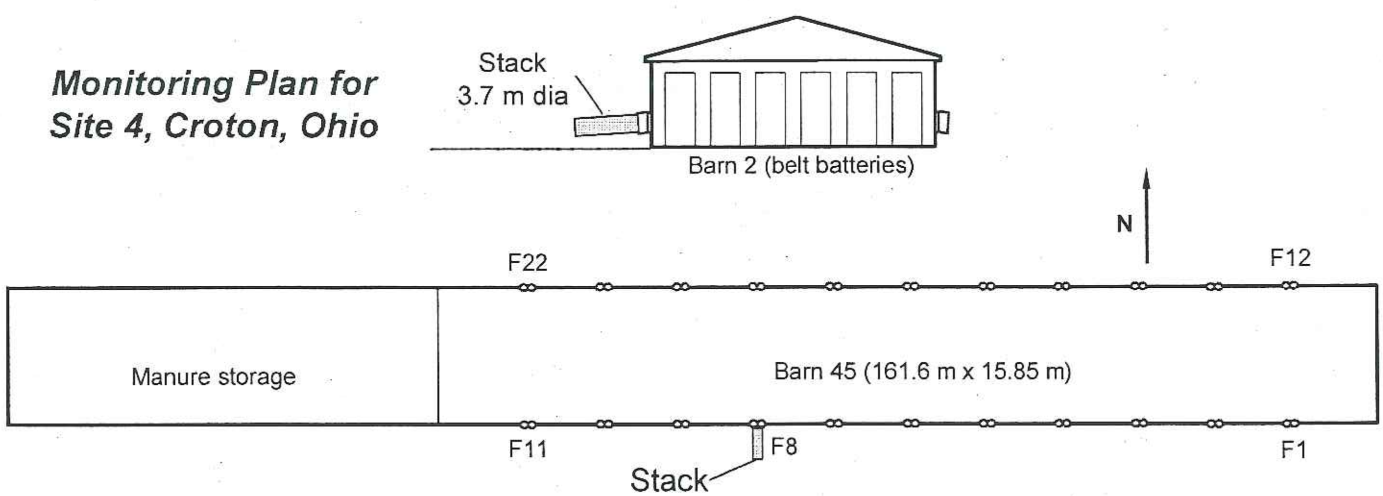


Figure A3. Monitoring plan for stack sampling at Barn 45, Site 4, Croton, OH.

Location of Sampling Ports and Traverse Points

EPA Method 1, "Sample and Velocity Traverses for Stationary Sources," will be used to select representative sampling ports and traverse points. Based on this method, the cross section of the sampling duct will be divided into a number of equal areas. Traverse points are then located within each of these equal areas. No traverse points shall be within 1 in of the duct walls. As suggested by the method, verification of absence of cyclonic flow will be conducted only if there are the following near the duct: 1) cyclones and inertial demisters, or 2) tangential inlets of other ducts which tend to induce swirling. However, cyclonic flow will be checked since all axial-flow propeller fans tend to create at a small amount of swirl.

A temporary discharge duct will be connected to fan 8 for emission measurement, Figure A4. The temporary duct is 12 ft (3.7 m) long with a diameter of 4 ft (1.2 m). Two sampling ports which are located 90 degrees apart on the duct will be used for traverse sampling. The sampling ports will be located 8 ft (2.4 m) or 2.0 duct diameters downstream from the fan discharge air flow disturbance and 4 ft (1.2 m) or 1.0 diameters upstream from the exit, Figure A5. A total of 24 sampling points (12 along each traverse port) will be used to conduct a full velocity traverse for each test run. The sampling locations of each traverse port are given in Table A2.

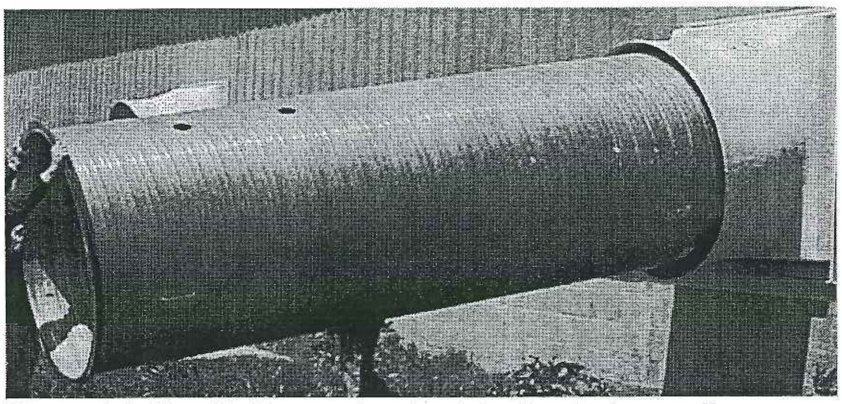


Figure A4. Fan discharge extension tube for stack sampling.

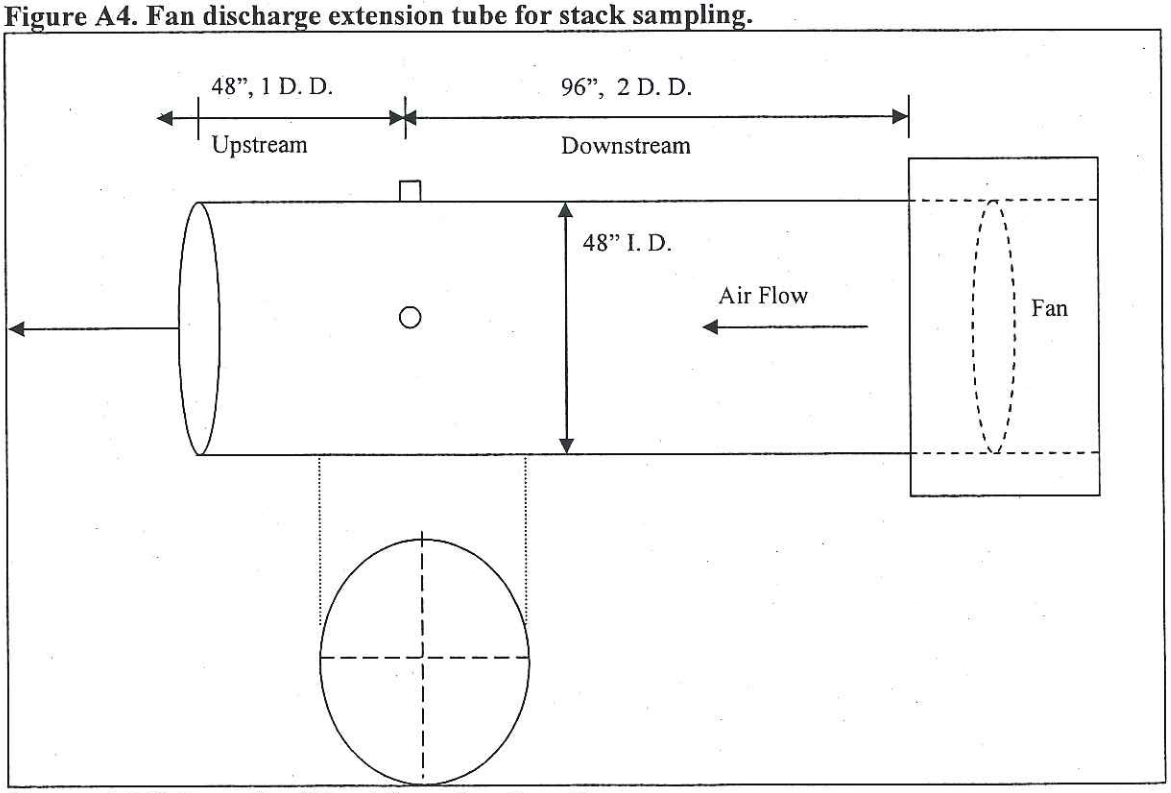


Figure A5. Schematic of Duct Sampling Locations

Table A1. Fan numbers and ventilation stages at Barn #45. The symbol > denotes a change made for this test.

Stage	Number	ID of fans for each stage
1	2	4>8, 19
2	2+2=4	8>4, 15
3	4+2=6	1, 22
4	6+2=8	11, 12
5	8+2=10	6, 17
6	10+2=12	2, 21
7	12+2=14	8, 15
8	14+2=16	3, 20
9	16+2=18	9, 14
10	18+2=20	5, 18
11	20+2=22	7, 16

Table A2. Locations of traverse points in the fan discharge extension duct.

Point No.	Percent of Diameter*, %	Point Location, in
1	2.1	1.0
2	6.7	3.2
3	11.8	5.7
4	17.7	8.5
5	25.0	12.0
6	36.5	17.1
7	64.4	31.0
8	75.0	36.0
9	82.3	39.5
10	88.2	42.3
11	93.3	44.8
12	97.9	47.0

* From inside wall to sampling point.

Average Velocity and Volumetric Flow Rate

EPA Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate," will be used to determine velocity and volumetric flow rate. A stainless steel, type "S" pitot tube, with an assigned coefficient of 0.84, and a pressure gauge in the Auto 5 sampler will be used to measure velocity pressure. An identification number shall be permanently marked or engraved on the tube. Since an inclined manometer will not be used in this experiment, the calibration of the pressure gauge will be checked before and after the test series. A minimum of three points pressure, representing the range of p values in the duct will be used. It is recommended, but not required, that a pretest leak-check be conducted. The leak test will be performed by first providing a 3.0 iwg or higher pressure, shutting off the opening, and check the pressure reading for 15 s. If the reading remains stable, the leak test is completed.

A calibrated Type "K" thermocouple will be used to measure stack gas temperature. The thermocouple will be attached directly to the pitot tube such that the tip does not touch any metal. The barometric pressure reading will be obtained from a nearby National Weather Service Station (Mansfield, OH). The average stack gas velocity will calculated from: the average velocity pressure; the average stack gas temperature; stack gas molecular weight; and absolute static pressure. The volumetric flow rate is the product of the mean velocity and the stack cross-sectional area.

Emission Rate Correction Factor, Dry Molecular Weight, and Excess Air

EPA Method 3, "Gas Analysis for Carbon Dioxide, Oxygen, Excess Air, and Dry Molecular Weight," will be used to determine CO_2 and O_2 concentrations, and dry molecular weight of the gas stream. Fyrite analyzers will be used to analyze grab samples collected during each test day. The chemicals used in the Fyrite analyzers are potassium hydroxide and chromous chloride. Extra care and attention will be taken when handling the Fyrite analyzers since the chemicals are corrosive.

Stack Gas Moisture Content

EPA Method 4, "Determination of Moisture Content in Stack Gases," will be used to determine sampling gas moisture content. This method will be conducted simultaneously with each particulate measurement run. The initial and final contents of all impingers will be determined gravimetrically. The impingers will be weighed to the nearest 0.1 g prior to and after sampling to the nearest 0.1 g. The increase in weight of the silica gel will also be recorded.

Particulate Matter

EPA Method 17, "Determination of Particulate Emissions from Stationary Sources," an in-stack filtration method will be used to determine filterable particulate matter. The sample train consists of a stainless steel nozzle, 47 mm in-stack glass fiber filter, probe, and a series of impingers followed by a vacuum pump, dry gas meter, and calibrated orifice. Particulate matter will be withdrawn isokinetically from the source and collected on a 47-mm dia. glass fiber filter at stack temperature. Thermocouples will be used to monitor temperatures of the stack gas, and impinger exit gas. The filter holder temperature will not be measured and recorded since it will be very similar to the stack gas temperature. A schematic of the sample train is shown in Figure A6.

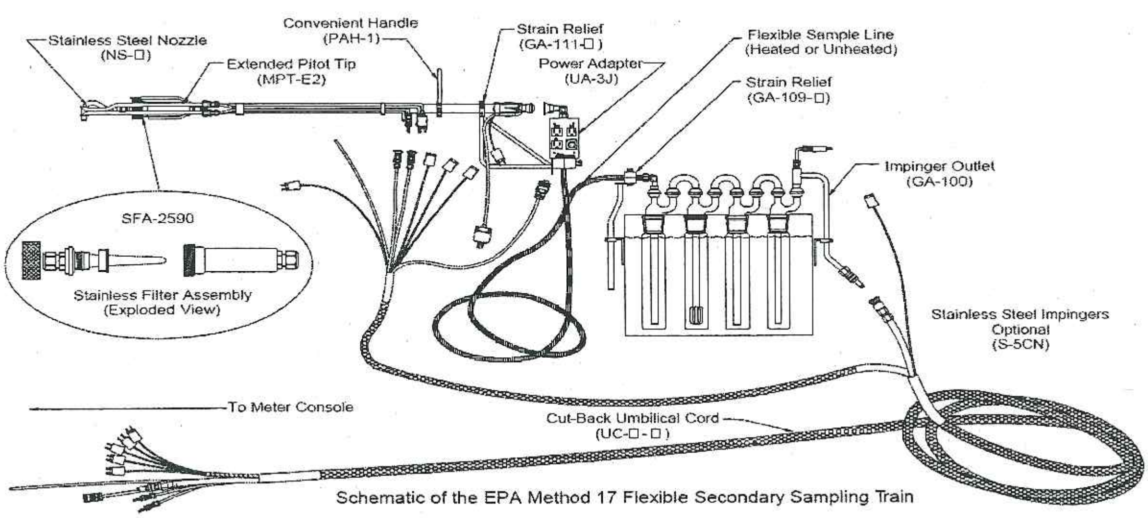


Figure A6. EPA Method 17 Sampling Train.

Assembly of the particulate sampling train was performed primarily in the sample recovery area. First, the clean empty impingers were assembled and configured in the proper order. Impinger Number 1 was a modified Greenburg-Smith impinger containing 100 milliliters of DI H_2O. Impinger Number 2 was a standard Greenburg-Smith which also contained 100 milliliters of DI H_2O. The third impinger was a modified Greenburg-Smith which remained empty; the fourth impinger was a modified Greenburg-Smith containing 200 grams of silica gel, and assembled in the cold section of the sample box and connected in series with U-tubes. Next, a 47 mm fiber filter was assembled in the filter holder and then placed on the end of the probe. The pitot tube was affixed to the nozzle-filter assembly with hose clamps.

The filter holder, probe, impinger box and other equipment will be transferred to the sampling location and assembled to the metering system. Ice will be placed around the impingers. The velocity pitot tube will be checked for leakage before sampling. The sample train will also be leak-checked prior to starting and at the conclusion of sampling.

To leak-check the assembled sampling system, the nozzle end will be capped, and a vacuum of approximately 15 in. Hg will be pulled on the system at the operating temperature for over 60 s after the system is evacuated. The filter holder will be inserted into the duct until there is temperature equilibrium. It is recommended that the leak rate to be less than 0.02 afm (actual ft^3/min). The cap will be slowly removed from the nozzle until the vacuum drops off. If the leak rate requirement is not met, the train will be systematically checked by first capping the train at the filter, at the first impinger, etc., until the leak is found and corrected. After the leak rate is determined, the leak rates and sampling start/stop times will be recorded on the data sheet. The sampling data for each point will be recorded.

As soon as the probe is removed from the sampling duct, proper cleanup procedure will be conducted by wiping off all external PM near the tip of the probe nozzle. A cap will be placed over the nozzle to prevent losing or gaining PM. Once in the recovery area, train will be inspected prior to and during disassembly, and abnormal conditions will be noted and recorded. The samples will be recovered as follows:

Container 1: 60-mm petri dish. The filter will be carefully removed from the holder and placed in the identified, matching number petri dish. A pair of tweezers or clean gloves will be used to handle the filter. The petri dish will be covered with the original numbered cover and sent to PAAQL for further analysis. –

Container 2: 250 ml container. Clean the inside surface of the nozzle and the front of the filter holder with acetone, and brush with a Nylon bristle brush. Brush until the acetone rinse shows no visible particles, after which a final rinse will be made. Brush and rinse the inside parts of the fitting with acetone similarly.

A portion of the acetone used for cleanup will be saved as blank. Chemically resistant glass bottles will be used for storing the acetone wash.

The volume changes of the water in the impingers will be determined by weight. Moisture captured by the silica gel will also be determined by weighing the impinger at the site using an electronic balance.

Particulate concentrations will be analyzed by measuring the PM collected in the acetone wash and filters. The acetone rinse from the probe and front of the filter holder (Container 2) will be evaporated at room temperature in glass beakers. Filters will be placed in a desiccator and weighed to a constant weight (<0.5 mg changes in weight). The components will be weighed separately using an analytical balance with a 0.1 mg resolution. The weight gains from the components will be combined to calculate the filterable particulate emission.

Other Quality Assurance/Quality Control

The preparation and calibration of the sampling equipment is essential in maintaining data quality. The following are brief descriptions of the calibration procedures used for this part of PM sampling.

Temperature Sensors

Bimetallic dial thermometer and Type "K" thermocouples will be calibrated at 0 and 50°C against a thermometer.

Pitot Tubes

Commercial Type "S" pitot tubes are constructed according to EPA Method 2 specifications. The pitot tubes meeting these criteria will be assigned a baseline coefficient of 0.84 and need not be calibrated.

Dry Gas Meters and Orifices

Dry gas meters and orifices will be calibrated in accordance with Section 3.3.2 of the QA Handbook. This procedure involves direct comparison of the dry gas meter to a reference displacement technique (wet test meter with capacity of 1 cubic foot per revolution). Before its initial use in the field, the metering system is calibrated over the entire range of operation. After each field use, the metering system is calibrated at a single intermediate setting based on the previous field test. Acceptable tolerances for the initial and final dry gas meter factors and orifice calibration factors are ±0.02 percent from the meter box factor and ±0.02 iwg variation from the average, respectively.

Appendix B: Abatement Tests in Conventional Laying Barn

The effectiveness of a Particulate Impaction System and other emissions controls on reducing PM emissions from conventional high-rise layer barns will be tested. The Particulate Impaction System consists of a weighted plastic sheeting and impaction media that together makes up an inner wall partition through which barn exhaust air must flow through.

The effectiveness of the Particulate Impaction System will be evaluated during a 7-day test in June, 2004 on one (1) fan at a deep-pit layer barn (barn 2) at the Mt. Victory Facility. This will be followed by a six-month, continuous emission test of the Particulate Impaction System at the same barn.

Description of Laying Barns at Mt. Victory, Ohio

Purdue University will measure emissions from two caged-hen laying barns at Mt. Victory, Ohio, 20449 County Rd 245, Mt Victory, OH 43340 (Figure B1). These laying barns were built in 1994 along with 12 other barns at the facility and are located 85 km from the OSU campus and 394 km from the Purdue University campus. The barns are oriented E-W and spaced 20.7 m apart (Figure B2). The roofs of the barns have a 4:12 slope. Each barn is 201 m x 20.7 m and houses 169,000 hens in eight rows of 4-tier crates in the 3.3-m high upper floor. Twice daily, manure is scraped off boards under the cages into the 3.2-m high first floor where it is stored for 12 months. Manure drying on the first floor is enhanced with eighteen, 918-mm dia. auxiliary circulation fans (Model VG36DM3F, J&D Manufacturing, Eau Claire, WI). The drying fans are arranged in two rows of nine fans each. Plans are to have four rows with 10 fans each by the end of 2004. Ventilation air enters the second floor from the attic through temperature and pressure adjusted baffled ceiling air inlets over each row of cages. There are twenty-five 48-in. (122-mm) dia. belted exhaust fans (fans #1-#25) (Advantage Fan Model AT481Z3CP, Aerotech, Lansing, MI) fans distributed along the south sidewall and twenty-five on the north sidewall (fans #26-#50), Figure B3. The fans are spaced 7.3 m apart. Each barn is currently ventilated in 26 rotating stages but will be modified according to Table A1. The first, second and third stages will consist of 1, 2 and 3 fans each. Eggs are removed on conveyors into the egg processing plant. The lights are shut off for several hours each night. Egg production and water and feed consumption are recorded automatically. Daily mortalities are recorded manually.

On May 3, 2004, the birds were 82 and 70 weeks old in Barns 1 and 2, respectively. Molting of hens in barn 1 had just been completed. Molting of hens in barn 2 was imminent. Barn 2 birds will be molted between the curtain test and the long-term monitoring.

Description of Particulate Impaction System

The Particulate Impaction System (Big Dutchman International GmbH, P.O. Box 1183, 49630 Vechta, Germany or P.O. Box 1017, Holland, MI 49422-1017) is a physical structure that resembles non-rigid ceiling-to-floor curtain/filter combination partitions, which are will be installed parallel to the manure pit sidewalls in the deep-pit layer barns. The filter portion of these partitions (Figure B4) reduces PM emissions by removing airborne particulate matter by impaction before the air is exhausted via the ventilation fans. The Particulate Impaction System will be constructed with a winch system so that the System can be raised or lowered depending on the volume of manure in the manure pits. The lower part of the partition will consist of heavy plastic to prevent air flow through it and will be weighted at the bottom to limit movement of the lower partition. The upper portion of the partition will be comprised of perforated cardboard filters to create sudden changes in airflow direction and force large particles to impact and drop out inside the filter.

Short-Term Preliminary Test

For the short-term preliminary test, a temporary Particulate Impaction System will be installed on fan 13 of barn 2, Figure B5. The dimensions of the Particulate Impaction System (upper part of wall partition) will be 40 ft x 6 ft (12.2 m x 1.8 m) for a total of 240 ft^2 (22.3 m^2). The partition will be located 42 inches (1.07 m) from the sidewall. The partition will be connected to the sidewall with a wood frame. One end of the enclosure will have a personnel access door. The enclosure will be sealed to force all the fan supply air to enter through the Particulate Impaction System. Based on a preliminary velocity traverse of the fan on May 4, 2004, and the published fan curve, the fan is estimated to have a flow rate of 23,000 cfm (10.9 m^3/s). At this flow rate, the air speed will be 0.48 m/s (96 ft/min) with the full area of the temporary curtain. The design air speed of 0.8 m/s through the curtain can be achieved by covering 40% of the curtain with plastic. When all the fans in the barn are operating in hot weather, each fan will be supplied by 24 ft (7.32 m) of curtain length. Assuming the curtain is 6 ft wide, then the speed of the air through the curtain will be 0.81 m/s. Because of operational control of the fans, the annual average number of fans is probably less than 50% of the total, resulting in lower air speeds. Ideally, the curtain would be tested at 0.8 m/s for four days and 0.4 m/s for three days. However, the minimum air speed is 0.48 m/s with the unobstructed curtain.

On the inlet side of the Particulate Impaction System, a TEOM 1400A PM-10 sampling head and microbalance, and a gravimetric TSP sampler (20 L/min) will be installed. Such devices will also be installed at the outlet side, between the Particulate Impaction System and the ventilation fan. The fan will be operated continuously and measurements will be conducted such that any difference between inlet and outlet TSP and PM-10 concentrations can be quantitatively determined to derive the PM control efficiency of the Particulate Impaction System. Although the inlet nozzles are interchangeable, the Gravimetric TSP Sampler has a fixed sample air speed. Isokinetic conditions are achieved by adjusting the position of the sample probes near the fan until the air speed at the probe nozzle inlet (14.5 mm diameter) is about 2 m/s (See SOP 16). For the inlet to the curtain, an open-faced, 25-mm filter holder (www.skcshopping.com/ProductDetails.asp?ProductCode=225-1109) can be used and will face upstream of the filter (away from the sidewall and fan). At 20 L/min, the inlet air speed into the open 25-mm filter holder will be 0.68 m/s. Isokinetic conditions will be achieved by adjusting the curtain opening to 71% so the curtain air speed matches the TSP inlet air speed, but this allows tests to be conducted at only one curtain air speed.

Alternatively, isokinetic conditions can be achieved by using the same approach used for the fan inlet and move the TSP sampling probes away from the curtain until the air speed matches the sampling air speed. For the 0.8 curtain air speed, the 25-mm filter holder would be moved away from the curtain until a speed of 0.68 m/s occurs. For the 0.48 m/s curtain air speed, a 37-mm filter holder would be moved away from the curtain until its sampling speed of 0.31 m/s occurs. The disadvantage is that the flow becomes more unstable with upstream distance from the curtain and the degree of instability will be measured using a portable hot-wire anemometer after the curtain is constructed. There is a possibility that fan effects will create a nonuniform air velocity profile through the curtain such that air speeds are higher near the fan. In this case, it may be possible to find the isokinetic air speed by moving further away from the fan toward the ends of the curtain while still remaining immediately upstream of the curtain.

Finally, the use of 22 and 30-mm nozzles in the 37-mm filter holders would provide isokinetic conditions for the curtain air speeds of 0.48 and 0.80 m/s. If these nozzles can be constructed in time for the test, then this approach will be used.

The sample integration time for the PM-10 analyzer will be thirty (30) minutes, and the integration time for the TSP samplers will be daily, or as determined on-site by filter loading.

The test will be conducted for seven (7) days to assess any variability in control efficiency as the Particulate Impaction System accumulates PM. A temporary shelter will be stationed next to the layer barn to provide space for the transfer of gravimetric filters to containers for off-site laboratory analysis.

Continuous Long-Term Test

The barns selected for continuous measurement are barns 1 and 2. Figure B3 shows a schematic of the monitoring plan for the two barns. The six exhaust locations will include three fans (F29, F38 and F47) on the north sidewall and three fans (F4, F13 and F22) on the south sidewall. Each exhaust location will be sampled individually with one tube whose end is located about 0.5 m directly in front of the fan at the same height as the fan hub. The ambient air sampling location will be located near the on-farm instrument shelter. The control sequence for these locations during each sampling cycle is given in Table B2.

A TEOM will be located immediately upstream of fan F38 of barn 1 and fan F13 of barn 2 heretofore denoted as the primary representative exhaust fans (PREF), Figure B3.

Capacitance-type relative humidity and temperature probes will be located at gas sampling locations 1 and 7, Figure B3. A solar radiation shielded RH/temperature probe and a cup anemometer and wind vane will be attached to a 10 m met tower near the trailer.

Thermocouples will be used to measure temperatures at exhaust fan locations 2-6 and 8-12, and at two locations in the second floor, the heated raceways between the barns and IS, the IS itself, and the instrument rack.

Barn static pressure will be measured between the center of the manure pit and both the north and south sides of the barn. The outside port will be located against the outside wall directly between two fans. These pressures will be different with northerly and southerly winds. Static pressure in the trailer will also be measured.

Fan operation will be monitored by sensing fan vibration using sensors mounted on each fan housing (100 total) in conjunction with digital inputs of the data acquisition system. Additionally, small vane anemometers (SVAs) will be installed on the six monitored exhaust fans of each barn and cleaned weekly.

Table B-1. Fan numbers and ventilation stages at Mt. Victory Barns #1 and 2 (control). Fans for stages 1 and 2 will be F38 and F13 to bring the stage 1 fan of each barn close to the IS. Fans 1-25 are on the south sidewalls.

	Existing Control Strategy		Proposed Control Strategy	
Stage	Fans/stage	Fan IDs	Fans/stage	Fan IDs
1	1	B1:38, B2:13	1	B1:38, and B2:13
2	1+1=2	B1:13, B2:38	1+2=3	B1:4,22, and B2:29,47
3	2+2=4	B1:4,22 and B2:29,47	3+3=6	B1:13,29,47 and B2:4,22,38
4	4+2=6	B1:29,47 and B2:4,13	6+4=10	B1:8,18,37,39 and B2:12,14,33,43
5	6+2=8	8, 20	10+4=14	B1:12,14,33,43 and B2:8,18,37,39
6	8+2=10	31, 43	14+6=20	2,6,10,16,20,24
7	10+2=12	2, 15	20+6=26	27,31,35,41,45,49
8	12+2=14	37, 49	26+8=34	1,7,19,25,30,34,42,46
9	14+2=16	9, 21	34+8=42	3,11,15,23,26,32,44,50
10	16+2=18	30, 42	42+8=50	5,9,17,21,28,36,40,48
11	18+2=20	3, 16	-	-
12	20+2=22	35, 48	-	-
13	22+2=24	10, 22>14	-	-
14	24+2=26	29, 41	-	-
15	26+2=28	4>1, 17	-	-
16	28+2=30	34, 47>50	-	-
17	30+2=32	11, 23	-	-
18	32+2=34	28, 40	-	-
19	34+2=36	5, 18	-	-
20	36+2=38	33, 46	-	-
21	38+2=40	12, 24	-	-
22	40+2=42	27, 39	-	-
23	42+2=44	6, 19	-	-
24	44+2=46	32, 45	-	-
25	46+2=48	13>7, 25	-	-
26	48+2=50	26, 38>44	-	-

Table B-2. Exhaust air stream control sequence during gas sampling cycle. Solenoids 1 to 12 direct air streams to either the bypass manifold (M1) or the sampling M2 (when "open"). A = barn 1. B = barn 2. Location 13 will sample ambient air twice daily.

Sol #	Location	Sampling period											
		1	2	3	4	5	6	7	8	9	10	11	12
1	A-F4	open											
2	A-F13									open			
3	A-F22					open							
4	A-F29							open					
5	A-F38			open									
6	A-F47											open	
7	B-F4		open										
8	B-F13										open		
9	B-F22						open						
10	B-F29								open				
11	B-F38				open								
12	B-F47												open

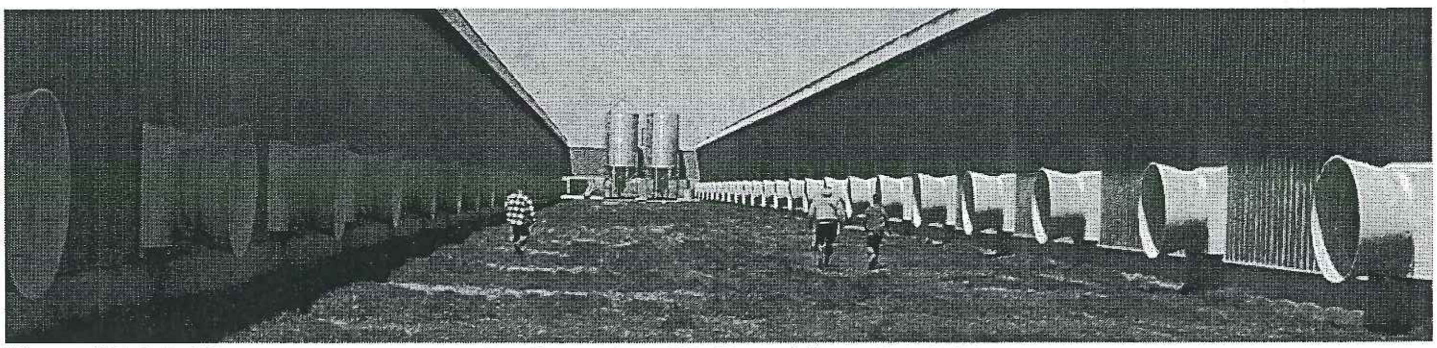


Figure B1. Mt. Victory measurement site, Barns 1 and 2. Barn 1 is on the right.

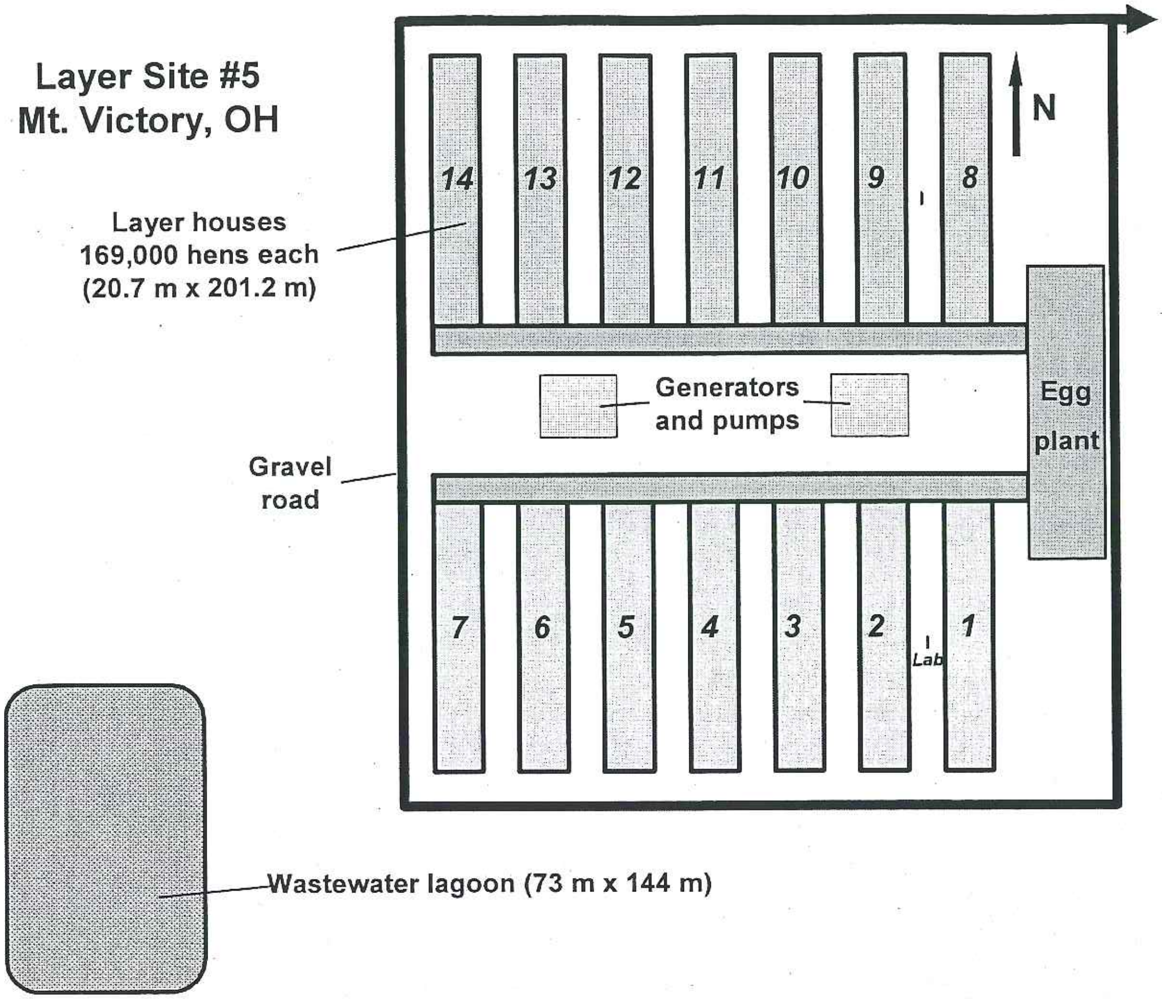


Figure B2. Layout of barns at Mt. Victory.

Monitoring Plan for Mt. Victory, Ohio

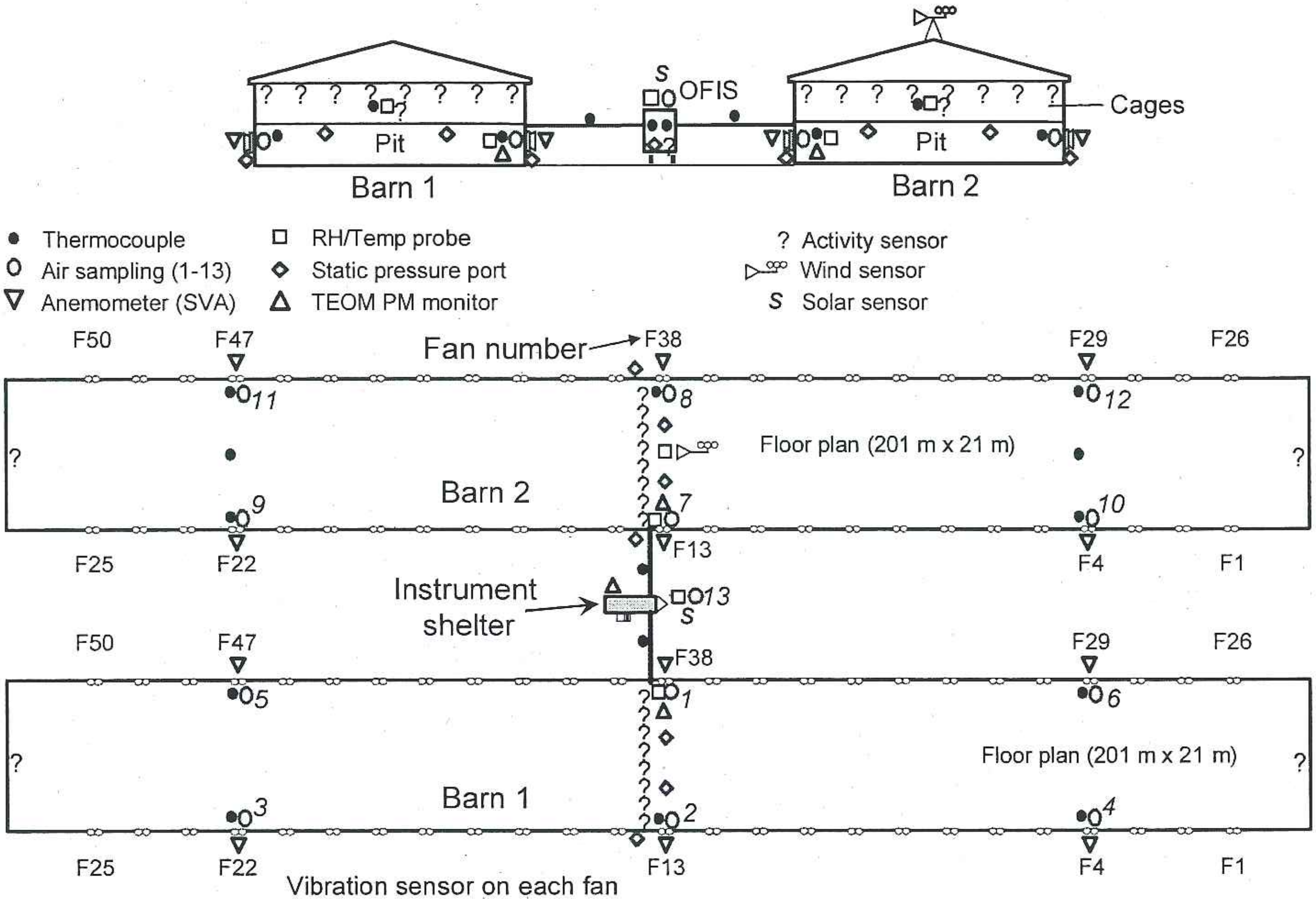


Figure B3. Mt. Victory monitoring plan for continuous measurements.

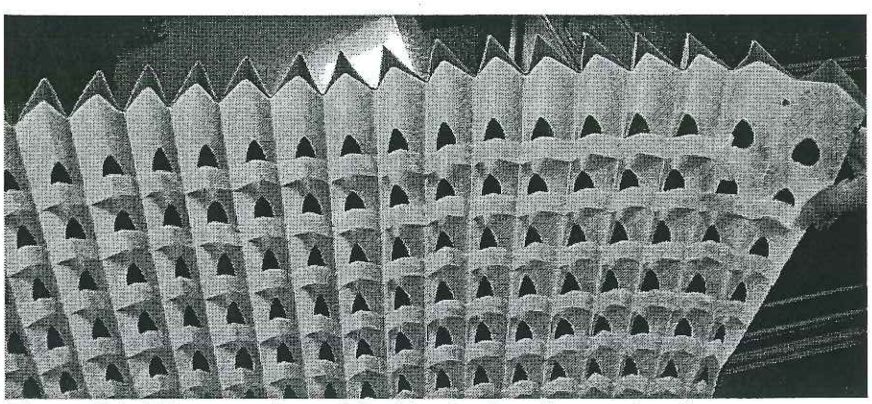


Figure B4. Filter portion of the Particulate Impaction System.

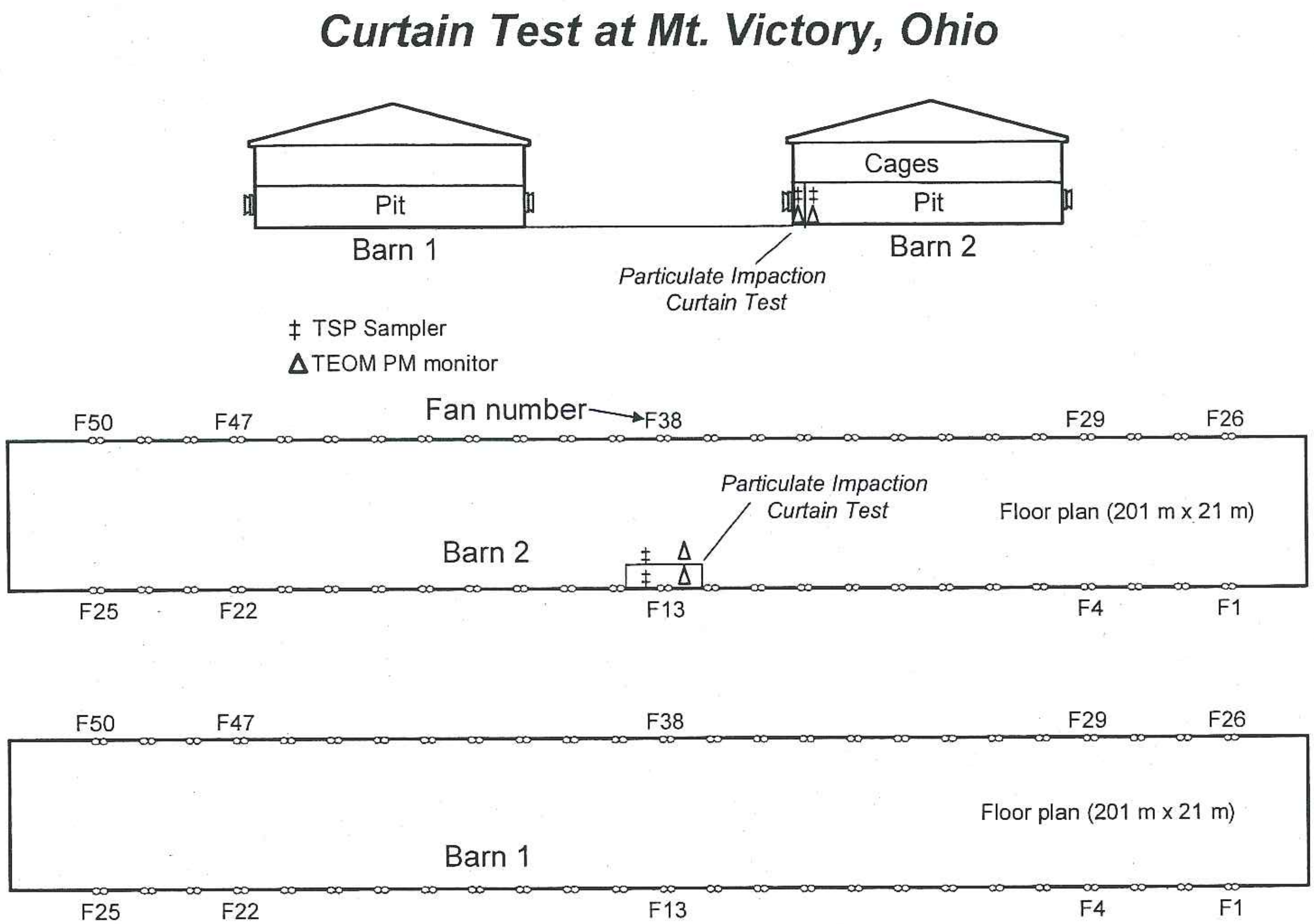


Figure B5. Mt. Victory monitoring plan for preliminary curtain test.

Appendix C: Abatement Tests in Belt Battery Laying Barn

Description of the Laying Barn Number 2 at Croton, Ohio

Purdue University with assistance from Ohio State University will measure emissions from a caged-hen laying barn at the Croton Facility (11995 Croton Rd, Croton 43013) which is supervised by Chris Art (740-893-7234) and managed by Ron Bishop, Figure C1. The laying barn is located about 63 km (39 mi.) from ohio State University (OSU) campus and 443 km from Purdue University. The barns are oriented N-S and spaced 15.9 m apart, Figure C3. The roofs of the barns have 4:12 slope. Each barn is 161.6 m x 15.85 m and will house 168,000 hens in six rows of 7-tier crates. Manure will be collected on plastic belts under the cages and removed from the barn in 1 to 5 days, since the belt travels 20% of the total distance every day and makes a full circle through the barn every five days. Air is blown on the belt to reduce manure moisture content. Blower capacity is higher in Barn #45. Ventilation air enters the second floor from the attic through temperature and pressure-adjusted baffled ceiling air inlets over each row of cages. There are 23, 48-in. (122-mm) dia. belted exhaust (Model GP48G600MNA, S.N. REVA 4-04, ValAir, 2599 Old Philadephia Pike, Bird 'N Hen, PA 17505)) fans (#1-#23) distributed along the west sidewall and 23 fans (#24-#46) on the east sidewall, Figure C3. The fan motors are 1 Hp (GE Model 5K49PN4442). The fans are 6.4 m apart. The barn has 12 temperature sensors and is ventilated in 12 stages, Table C1. Each stage consists of four fans except for stages 1 and 2, which have 3 fans each. Eggs are removed on conveyors into the egg processing plant. The lights are shut off for several hours each night. Egg production and water and feed consumption are recorded automatically. Daily mortalities are recorded manually.

The hens in barn 2 will be about 25 weeks old on August 1, 2004 and about 51 weeks old on February 1, 2005. Since molting does not occur until laying hens are 60 weeks old, molting will not occur during the tests.

Site Monitoring Plan

The barn selected for measurement is barn 2, which is one barn in a complex of sixteen barns that was built in 1982 and remodeled in 2004, Figure C2. Figure C3 shows a schematic of the monitoring plan for the barn. The six exhaust sampling locations will include three fans (F3, F7 and F11) on the south sidewall and three fans (F12, F16 and F20) on the north sidewall. Each exhaust location will be sampled individually with one tube whose end is located about 0.5 m directly in front of the fan at the same height as the fan hub. The ambient air sampling location will be located near the IS. The control sequence for these locations during each sampling cycle is given in Table C2.

A TEOM will be located immediately upstream of fan F7 heretofore denoted as the primary representative exhaust fan (PREF), Figure C3.

Capacitance-type relative humidity and temperature probes will be located at gas sampling location 7, Figure C3. A solar radiation shielded RH/temperature probe and a cup anemometer and wind vane will be attached to a 10 m met tower near the trailer.

Thermocouples will be used to measure temperatures at the odd numbered exhaust fans on the south sidewall and the even numbered exhaust fans on the north sidewall, the heated raceway between the barn and IS, the IS itself, and the instrument rack.

Barn static pressure will be measured between the center of the manure pit and both the north and south sides of the barn. The outside port will be located against the outside wall directly between two fans. These pressures will be different with northerly and southerly winds. Static pressure in the trailer will also be measured.

Fan operation will be monitored by using vibration sensors mounted on each of the 46 fans in conjunction with digital inputs of the data acquisition system. Additionally, SVAs will be installed on the six monitored exhaust fans of each barn and cleaned weekly.

Table C-1. Fan numbers and ventilation stages at Croton Belt Battery Barn #2.

Stage	Number	ID of fans for each stage
1	2	4,12
2	2+2=4	20,39
3	4+3=7	25,31,45
4	7+3=10	8,16,35
5	10+4=14	11,13, 28,42
6	14+4=18	1,23,33,37
7	18+4=22	6,18,26,44
8	22+4=26	2,22,30,40
9	26+4=30	7,17,24,46
10	30+4=34	5,19,34,36
11	34+4=38	10,14,29,43
12	38+4=42	3,21,32,38
13	42+4=46	9,15,27,41

Table C-2. Exhaust air stream control sequence during gas sampling cycle. Solenoids 1 to 6 direct air streams to either the bypass manifold (M1) or the sampling M2 (when "open"). Location 7 will sample ambient air twice daily.

Sol #	Location	Sampling period					
		1	2	3	4	5	6
1	F7			open			
2	F11	open					
3	F16		open				
4	F3					open	
5	F12				open		
6	F20						open

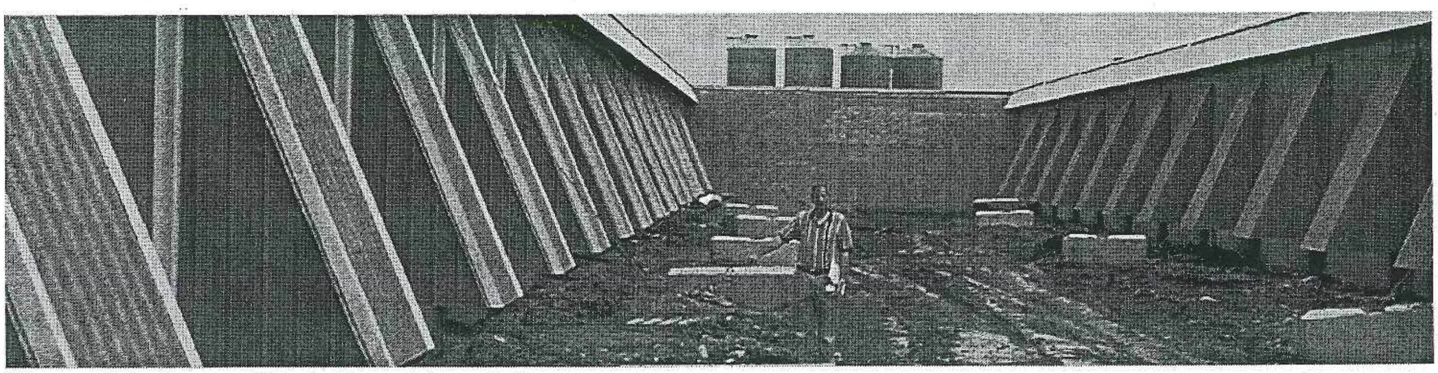


Figure C-1. Croton Site 1. Barn 2 is on left.

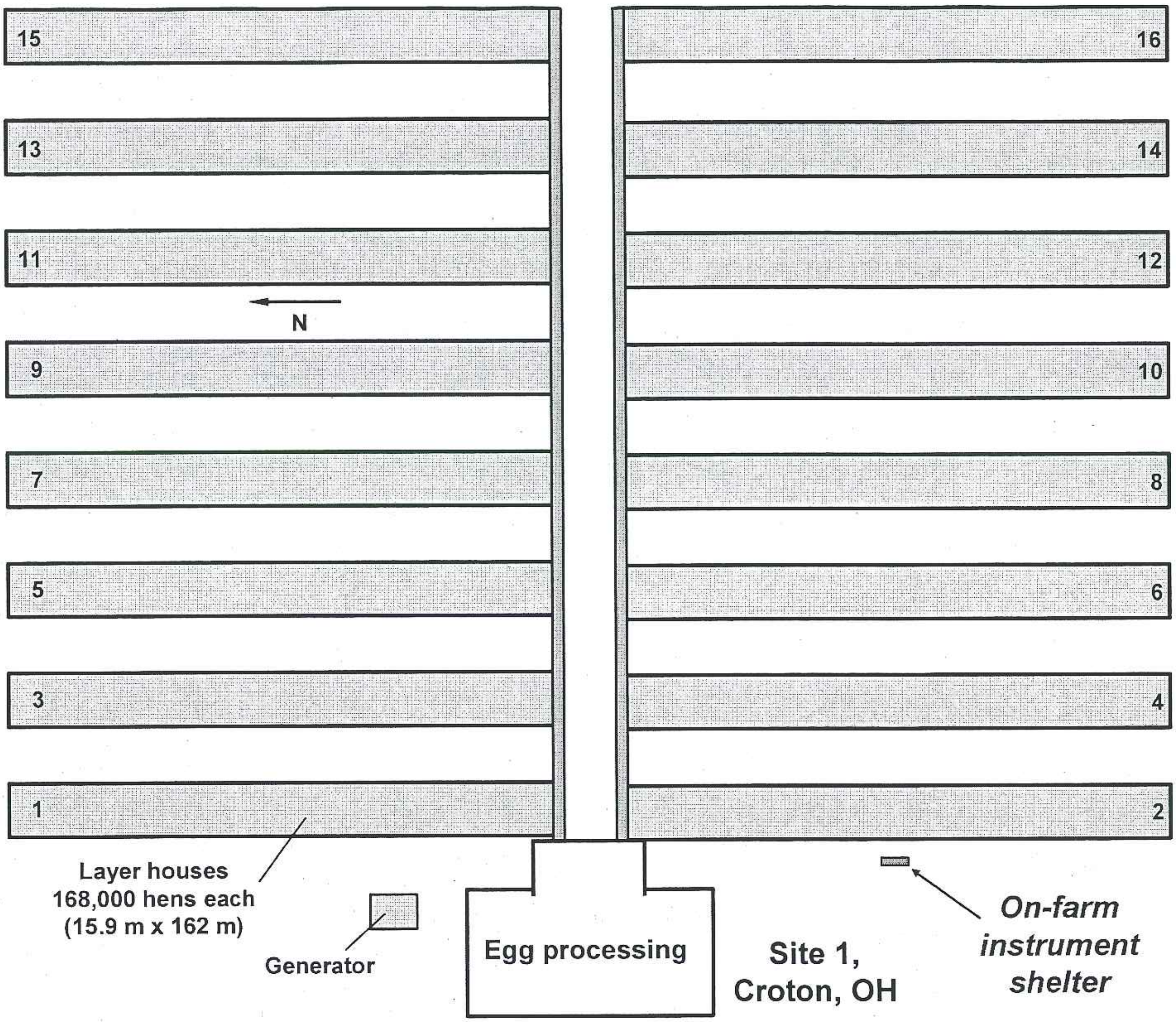


Figure C-2. Layout of barns. Continuous emissions will be measured at barn 2.

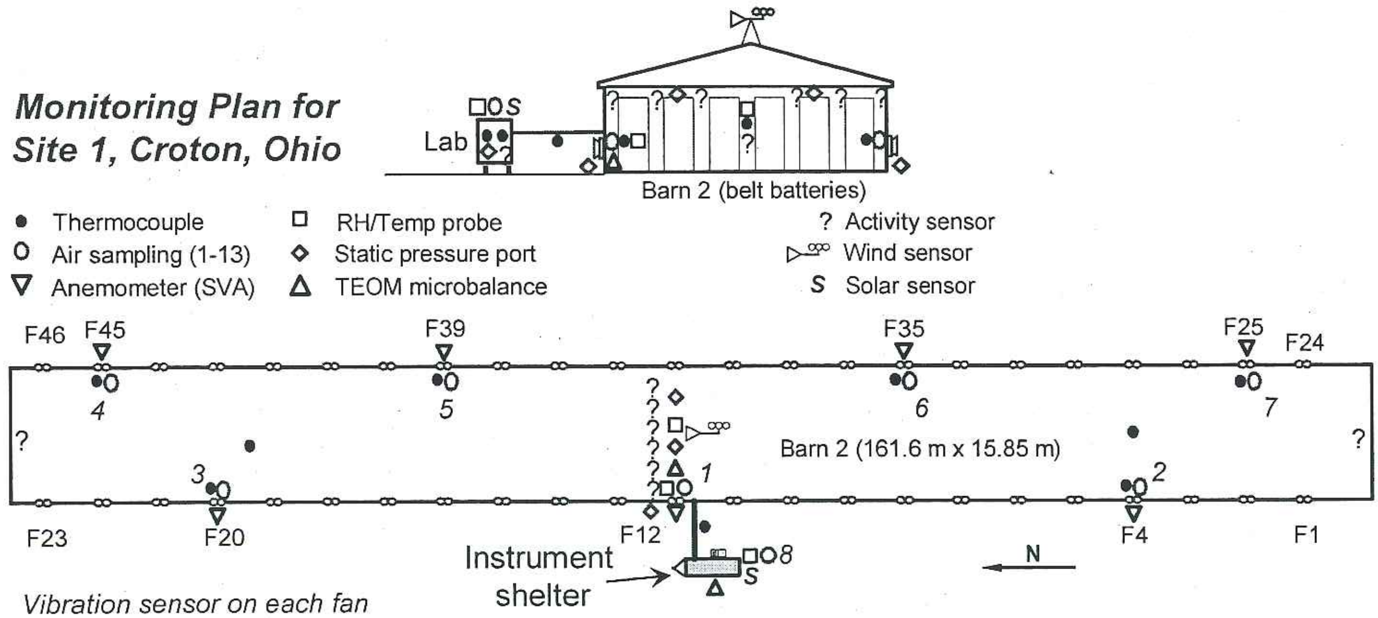


Figure C-3. Site monitoring plan for continuous air emission testing at barn 2 at site 1 near Croton, OH.

Appendix D: Laboratory Testing of EcoCure
Purdue Agricultural Air Quality Laboratory (PAAQL)
April 24, 2004

This standard operating procedure covers the manure reaction tests conducted over a period of 38 days.

Experimental Design

The experiment will be a test of a single manure enzyme additive product, Eco-Cure, for a 38-day period with four controls and four treated reacotors (four replications) at one constant temperature in the manure reactors (experimental unit). Both controls and treated reactors will be using chicken manure from the same facility. The bagged manure transported to the test site will be randomly selected for each reactor.

Reactor Room

The reactor testing will be conducted in the agricultural air quality laboratory in Room 102 of the Agricultural and Biological Engineering Building. A 14.5x9 ft insulated walk-in chamber, located in Room 102A immediately outside of Room 102E, will contain the reactors, Figure D1. A total of twenty reactors, of which eight will be used in this test, will be located along the north inside wall and the center of the chamber.

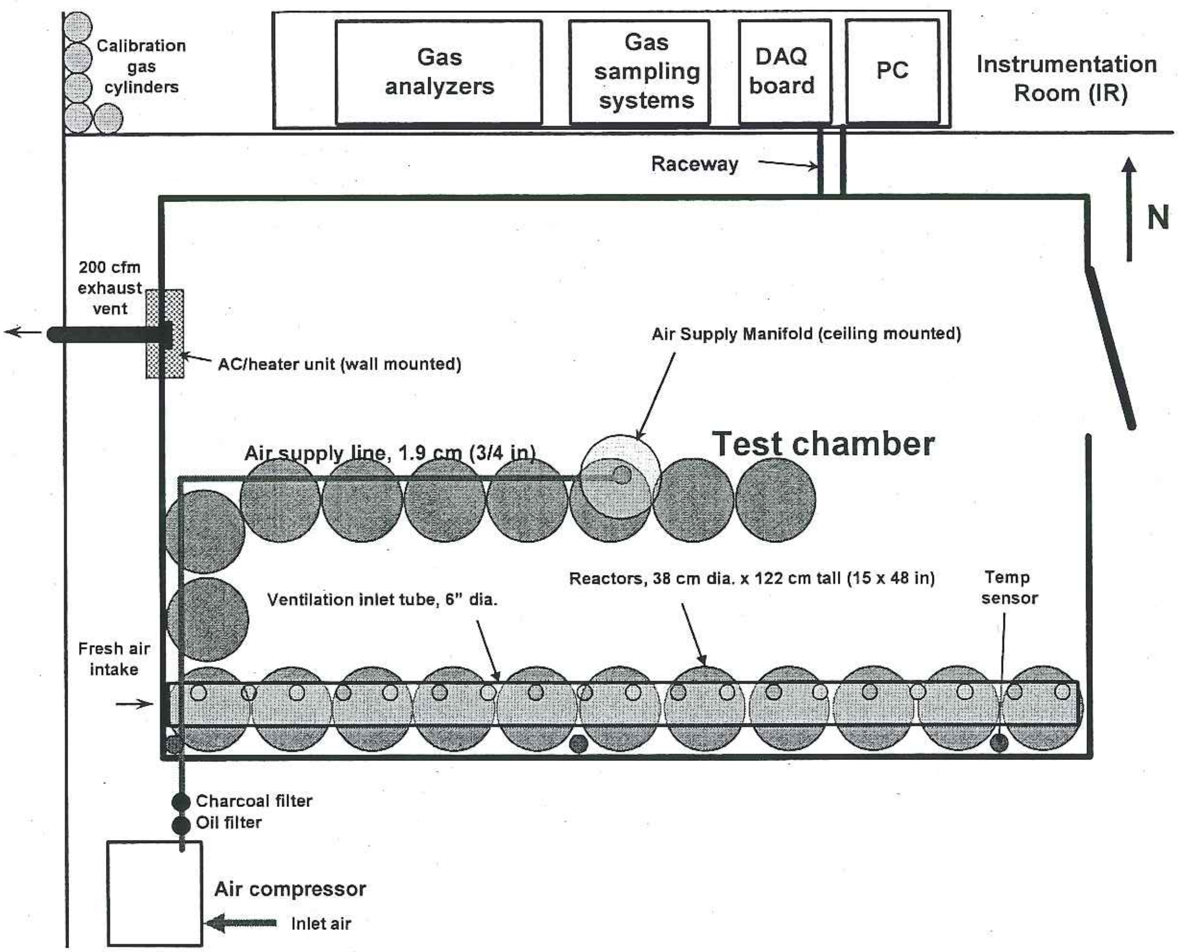


Figure D1: Floor plan of the experimental facilities.

The reactor room will be held at 68°F or 20°C. A manually-controlled variable-speed exhaust fan (200 cfm or 340 m^3/s) will vent fumes to the outside of the ABE building and draw in fresh inside air to the room. The makeup air will enter the room through a six inch diameter perforated tube which is suspended from the ceiling and admits ambient air from one end of it.

Reactors

Physical Description

The reactors are made of hard 50-psi PVC plastic pipe (SDR 81, 15.3" o.d., 14.922" i.d.) with 50 psi caps made of the same material. Each reactor is nominally 15 inches in diameter and 48 inches tall, Figure D2. All air plumbing fixtures will be stainless steel for the ventilation inlet air system. All air plumbing fixtures and tubes will be Teflon for air leaving the reactor and flowing to instruments except for the stainless steel type 316 wetted surface of the mass flow meter (McMillan Model 50S, 0-10 Lpm). All air inlet tubes are Teflon and the air inlet fittings are Kynar. The caps of the trap and bag sampling port will be white polypropylene, the same material used for the bag fittings.

Each reactor will be lined with new 2 mil Tedlar film on the top 25 inches of the inside walls and the "ceiling" of the reactor to create a chemically inert headspace. The Tedlar will be held in place with 0.25 and 1.0 inch spring stainless steel bands at the top and bottom of the cylinder.

The air inlet will include a baffle to direct the air radially in all horizontal directions. The baffle opening required to maintain a constant jet momentum number in the headspace ranges from 0.1 to 0.2 inches. A ¼" thick, 2" diameter plastic knob at the top of the ventilation inlet system will be used to adjust the baffle opening. The knob will have a mark on it at one location on its circumference. An adjustment of 3.2 clockwise rotations of the knob moves the baffle downward 0.1 inches.

Each reactor headspace will be continuously ventilated about 7.0 L/min. The air inlet opening will be adjustable and telescoping to allow the inlet to always be located six (6) inches above the manure surface.

A male adapter will be inserted directly into the PVC cap as air exhaust port, Figure D3. A filter holder with a filter support mesh will be installed in line with the gas sampling tube to remove manure flies.

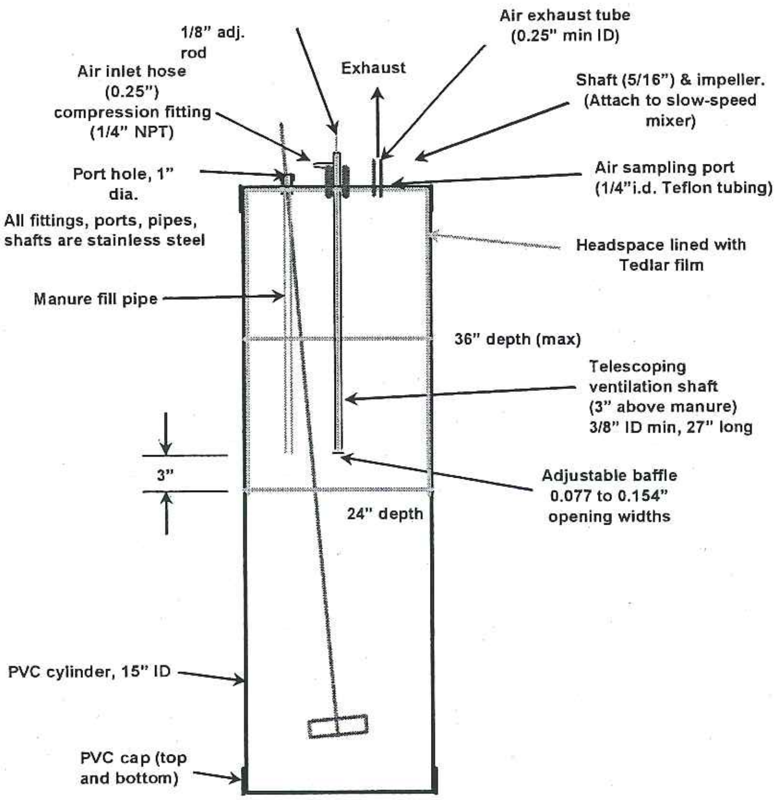


Figure D2: Reactor used for both liquid and solid manure. Stirring paddle and manure fill pipe for liquid only.

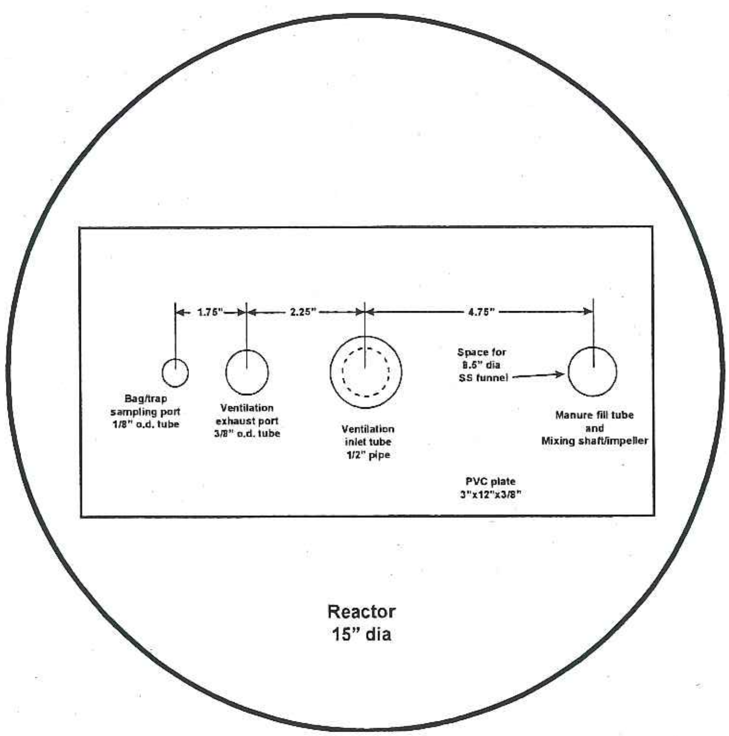


Figure D3: Fittings on top of reactor.

Ventilation Air Control

Odor-free ventilation air will be supplied by a 7.5 Hp air compressor, located just outside the reactor room, with an air pressure of 90-120 psi with a maximum delivery rate of about 20 cfm at 150 psi. The source air will be taken from the air outside the reactor room, Figure D4. The oil in the air will be filtered out with a coalescing filter to a concentration of 0.01 ppm. A water trap will remove condensed liquid water. An activated charcoal filter (located will remove odor. Since there may be some heating of air from the compressor motor, sufficient length of ventilation air supply tube (0.25 inches ID) will be located in the room to allow the air to cool before entering the reactor. The filters will be replaced at the beginning of each cycle.

The pressure of the ventilation air will be reduced and stabilized with two pressure regulators. The first regulator (±3%) will reduce the pressure to 20-50 psi. The second regulator (±0.25%) will reduce air pressure to 5-7psi and supply air to an air supply manifold.

The air supply manifold is used to distribute air with constant pressure to all reactors. Stainless steel precision orifices (0.033", O'Keefe #G-33-SS) are connected in parallel to the manifold to control airflow rates to each reactor. Each orifice was individually calibrated for airflow rate at 6 psi with a 20 – 6000 mL/min Gilian Gilibrator-2 Calibration System (Sensidyne, Clearwater, FL), which was factory-calibrated, prior to use. The error of airflow rate of each orifice was <±1% of the mean airflow rate of 40 orifices installed in the manifold at 6 psi. Orifices with airflow rate errors >±1% of the mean were replaced.

A Teflon tube of 1/4" ID (3/8" OD) is used to transport air from the orifices to the reactors. Each tube is 10 feet long.

Filling the Reactors

Twenty-six inches of manure will be added to each reactor on day zero. Manure, transported to the test site with boxes between 28 lb and 44 lb, will be randomly allocated to each reactor. About two inches or 7.5 lb of manure will be added to each reactor on days 7, 14, 21 and 28 according to the following schedule:

Day	Quantity (inches)	Depth in reactor (inches)	Baffle opening, in.	Number of turns from closed pos.
0 (Tue)	26	26	0.115	3.7
7 (Tue)	2	28	0.134	4.3
14 (Tue)	2	30	0.150	4.8
21 (Tue)	2	32	0.166	5.3
28 (Tue)	2	34	0.184	5.9

The reactors will be loaded to a maximum level of thirty-four (34) inches throughout the test to allow a minimum of fourteen (14) inches of headspace. The time and order of filling will be recorded on the manure handling record sheet.

The reactor caps will be removed to add the two-inch additions of manure. Exactly 7.5 lb weighed by equivalent volume of 5.76 L of manure will be added. Bags of 7.5 lb manure will be randomly selected for each reactor.

Sampling and Measurement

Air Sample Stream Transportation

A continuous air stream from the exhaust of each reactor will flow under slight pressure through a 23 ft long 5/16" ID (3/8" OD) Teflon tube to the inlet port of a computer-controlled three-way Teflon-lined solenoid (1/8" NPT, 5/32" orifice, 24 VDC, Cole-Parmer #P-98300-42, Cole Parmer, Chicago, IL) in the Instrument Room (room 102E). One outlet port will be connected to the atmosphere and exhausted through the laboratory hood. Another outlet port of the solenoid will be connected to the gas sampling manifold.

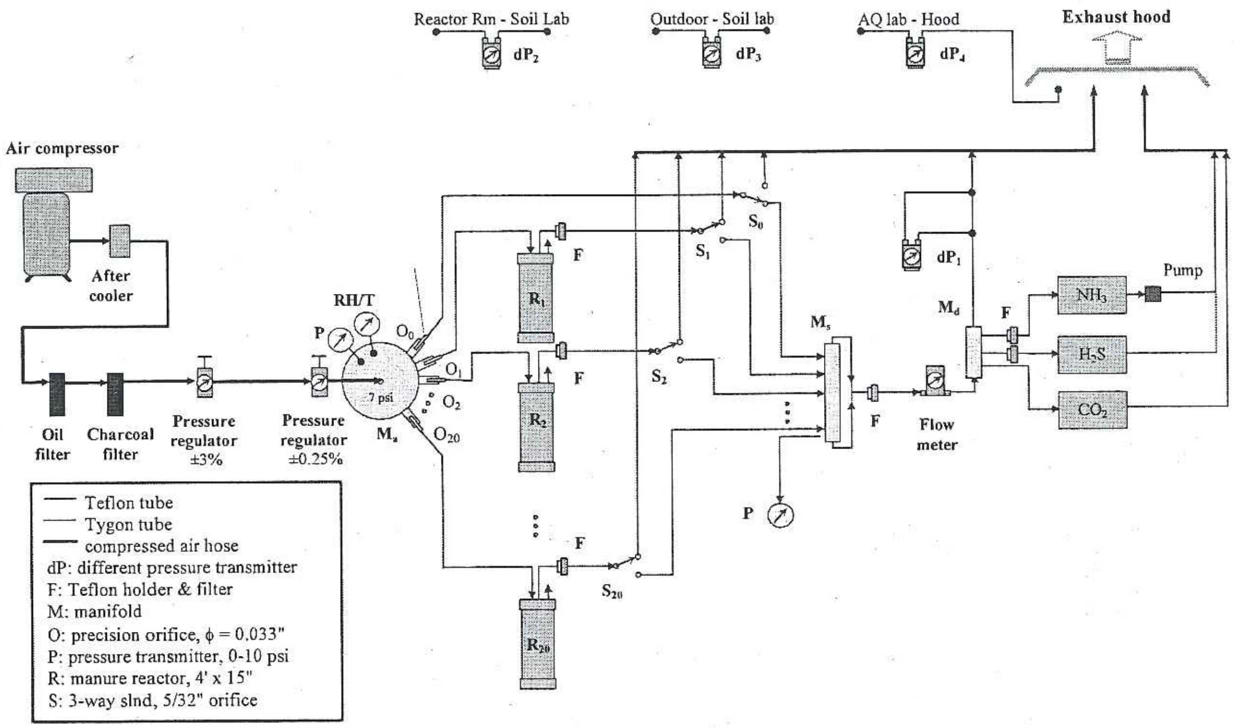


Figure D4: Test diagram.

The internal or external pumps of the gas analyzers will pull air from the gas manifold through Teflon tubes. The total airflow rate drawn by the analyzers (< 3 Lpm) will be significantly less than the airflow rate passing through the manifold. The total airflow from the reactors will not be significantly affected by the air sampling.

Blank air samples from the air supply manifold will also the sampled. Blank air will be transported to an air sample control solenoid through a Teflon tube of 1/4" ID (3/8" OD).

Gas Sampling Period

The sample air stream from 20 reactors will be measured continuously for ten (10) minutes each before switching to another reactor. The first seven minutes of gas concentration data will be ignored to allow the measurement system to equilibrate. The air sample from air supply manifold will be sampled thirty (30) minutes. It will require 230 minutes (three hours and 50 minutes) to scan through all air sources. A little more than six measurements will be obtained daily for each reactor during a typical day of measurement, excluding weekly manure addition days and other system maintenance days.

Temperature, Relative Humidity and Pressure

The air temperature in the reactor test room will be monitored in four locations with thermocouple temperature sensors.

An electronic RH/temp probe (Humitter 50 YC, Vaisala, Woburn, MA) will be installed inside the air supply manifold to monitor air temperature and relative humidity.

Six pressure sensors will be used to monitor the test syetem. The first one(0-10 psi precision, 0.25% accuracy pressure transmitter, WIKA, Tronic Line) will be monitoring and recording pressure inside the air supply manifold (Ma)

The second one will monitor pressure in the air sampling manifold (Ms) and the third one will monitor the different ial pressure at the exhaust air of the distribution manifold (Md) to insure sufficient air supply during analyzer calibration.

Other pressure sensors will monitor the exhaust hood, reactor room and the instrument room pressure.

Airflow Rate

A mass-flow meter (0-10 Lpm, Model 50S-10, McMillan, Georgetown, TX) will be used to measure the airflow rate from each reactor for six minutes every four hours, when the gas concentrations of the reactor are being measured.

Gas Analyzers

NO Converter and NH3 Analyzer

Ammonia will be measured with an ammonia analyzer (TEI Model 17C) according to SOP 3. The NH3 analyzer will be set at 0-200 ppm measurement range.

Chillgard IR Refrigerant Leak Detection System

The Chillgard IR Refrigerant Leak Detection System (Mine Safety Appliances Company, Pittsburgh, PA) is based on photoacoustic infrared sensing technology. The unit in this study was manufacturer serviced and calibrated on Feb 11, 2002 before the test. Its display resolution is 1 ppm and measurement range is 0-1000 ppm. This measurement system will be used for ammonia concentrations higher than 200 ppm.

Additional Gas Analyzers

Beside the required ammonia measurement, other gas analyzers, an H2S analyzer and a CO2 analyzer, will be used to provide auxiliary information to the assessment of additive effect on manure, but are not required.

H2S Converter and SO2 Analyzer

Hydrogen sulfide will be converted to sulfur dioxide (SO2) with a converter (TEI Model 340). The SO2 will be measured with the pulsed fluorescence method (TEI Model 43 SO2 Analyzer). Hydrogen sulfide will be measured with an accuracy of 1.0% of full scale or ±25 ppb. Higher full scales can be selected if necessary.

CO2 Analyzer

The accuracy of the photoacoustic infrared carbon dioxide analyzer (Mine Safety Appliances) is ±100 ppm. Its normal measurement range is 0 – 5000 ppm and will be extended to 0-10,000 ppm in this study.

Calibration Gases and Analyzer Calibration

The following calibration gases will be used:

- Nitrogen for zero concentration check for all analyzers;
- Certified 73.9 ppm ammonia balance air for ammonia analyzers' span check;
- Certified 1.15 ppm hydrogen sulfide balance nitrogen for hydrogen sulfide span check;
- Certified 3.8 ppm sulfur dioxide balance nitrogen for sulfur dioxide span check;
- Certified 9013 ppm carbon dioxide balance nitrogen for carbon dioxide analyzer span check.

Calibrations will be conducted prior to the test and weekly during the test on all analyzers for zero and span.

Data Acquisition and Control

The data acquisition system and control (DAC) will consist of a personal computer, Field Point data acquisition and control hardware (National Instruments Co. Austin, TX), and software (LABVIEW, National Instruments Co. Austin, TX). A DAC program for this test will be written with LabVIEW. Measurement data will be sampled every second and averaged every 15 seconds and 1 minute. The 15-second and 1-min data will be saved in two saparate data files. The DAC program will control the solenoids for automatic air sampling.

Data

Raw data for this test are either recorded manually or collected automatically by a personal computer. Manually recorded data will be entered into computer spreadsheets. Automatically recorded data by the DAC program will initially reside on the data acquisition computer. Both the manually and automatically recorded data will be backed up on a computer drive that is automatically backed up on tape every night of every business day.

Processing of measurement data will be done following the 38-day testing period using a software computer program developed by PAAQL personnel. Gas concentrations in each reactor will be separated and arranged chronologically. Temperature, relative humidity and static pressure will be calculated.

Additive Preparation and Application

EcoCure, the solid manure additive, will be prepared and applied to the reactors according to the instruction provided by the manufacturer.

Preparation

Eco-Cure solution: Prepare 15.0 g of Eco-Cure in 2 L of water at 95 F for at least 5 h. (Conversion from manufacturer required 0.5 oz product in 1 gal of 95 F water: 1 oz = 28.35 g, 1 gal. = 3.79 L).

The Eco-Cure product will be weighed with a lab grade balance and put into a manufacturer-provided sock. The sock containing Eco-Cure will be submerged into the water and will be squeezed several times to get a tea-like liquid.

Application

The quantity of application will be:

- For initial application: 35 mL each reactor.
- For weekly application: 15 mL each reactor.

A hand pump spray purchased from Wal-Mart will be used to apply the additive. One pump will spray approximately 3 mL. Application will follow the weekly manure addition on Tuesday, about two (2) hours after the manure addition is finished.

The spray application procedure will be thoroughly tested to assure that the correct amount of solution can be sprayed with the proper coverage on the surface of the manure. Pressure will be variable and the appropriate type of nozzle can be installed. The reservoir can be replaced with a more appropriate reservoir based on the amount of solution to be applied.

Quality Assurance and Control

Sampling and Measurement

On-line results of all the continuous measurement variables will be displayed on the PC screen. The status of the test (temperature, airflow rate, pressure, etc.) and real-time measurement data as displayed on the screen of the DAQ computers will be visually checked at least twice a day including weekends either in the lab or remotely using PCAnywhere™ software.

In addition, the reactions will be checked each business day. The items checked for proper operation will be as follows: 1) Compressor and reactor ventilation system, 2) Ventilation of reactor room and 3) temperature of reactor room.

The automatically recorded gas concentration and temperature data will be graphically printed on paper every business day using an Excel macro program. The printed graphs will be visually checked for measurement errors and system problems.

Test notes will be recorded whenever there will be planned and executed activities or observed activity or environment changes that may affect the test. Each item of note will include date, time, detailed description or data recording, and name of the recorder.

Manure Addition and Additive Application

Manure was collected initially from Mt. Victory Site 4, Barn 9 where the manrue windrows were two to four feet high. The manure will be taken from rows 2 to 4 near the back of the barn. Manure from the surface to the core of the pile was put into boxes with plastic liner and sealed. It was collected in the early morning, and transported by truck to Purdue University the same day.

For the last addition, manure was collected from Barn 10 from the back of the barn. This manure was heavily populated with house fly larvae and had greater moisture content.. As a result, the texture of the manure was that of coffee grounds. It was noted by the worker that the manure in barn 10 emitted much more odor than the manure collected from barn 10.

At least three people will be present to initially fill the reactors with manure. At least two people will be present at each weekly manure addition and additive application. They will work together according to the SOP, monitor the mixing operation, and observe and record the time, sequence and success of reactor filling and additive application.

Safety

PAAQL personnel working with the manure will wear protective clothing appropriate for handling hazardous liquid material. Any spills no matter how small will be cleaned up immediately. The reactor ventilation exhaust air will be contained and removed from the building through the canopy hood in Room 102E.

Appendix E: Supervisory Audit of Emission Measurement Sites

Date:
Site:
Auditor(s):
Researchers present during visit:

Project Management

Start date:
Frequency of online data observation:

Analyst(s) training:

Data available at site for inspection?
Is data being inspected following business day?
Is manual entry log book being maintained? Permanent ink?

Characteristics of producer collaboration and cooperation:
Is producer providing the following?

mortalities Yes _____ No ______
animal inventory and weight Yes _____ No ______
production (e.g. eggs) Yes _____ No ______
water and nutrient consumption Yes _____ No ______

occurrence of special activities, e.g., generator tests, manure removals or agitation, change in diet and animal health, temperature set points, ventilation interventions, barn cleaning, power failures, etc.?
Yes _____ No ______

Data Management

All files under one folder in the PC?
Data and files backed up in case of hard drive failure?
Are data files emailed to campus daily?
Are important project files (hard copy and electronic files, including data, program, field notes, emails, etc.) backed up and stored away from instrument shelter (e.g. on campus)?

Instrument Shelter

Cleanliness and orderliness:
SOPs displayed near instrument? Yes _____ No ______
Security:

Utilities:
Environmental control:

Electrical power protection:

Gas Sampling System

Date of last leak test:
Visual appearance:
Pressure sensor:
Mass flow sensor:
Flow rate (minimum = 3.6 L/min) = ________ L/min.
Are gas sampling locations randomized? Yes _____ No ______
Has response time been tested? Yes _____ No ______
Spare parts?

- Sampling pump
- Solenoids
- Pressure sensor
- Mass flow meter

Description of gas calibration system:

Sampling interval, min:
Number of gas sampling locations:

Using mixing manifolds?

How are gas and vacuum sampling lines heated, 3 C above sampled air, etc.?

Calibration Records

Instrument	Calib.* interval, days		Most recent	Loc	n	r	Notes
	QAPP	Actual					
CO_2							
NO							
NH_3							
TEOM microbalance							
Pressure zero check							
Pressure span							
TC							
RH/Temp							
Mass flow meter							
M2 pressure sensor							
TEOM vs FRM							
Check point C (bag)							
TEOM airflow							
TEOM leak test							
TEOM barometer							

*Or verification. B/A = before and after the test. S/W = once in summer once in winter. FC = at every filter change

Control charts available for gas analyzers? Yes _____ No ______
Calibration records available in shelter? Yes _____ No ______
Log of calibration times? Yes _____ No ______
Are all gas cylinders valid (not expired?) Yes _____ No ______
Regulators dual valve stainless steel? Yes _____ No ______

Barn Inspection

Check location of inlet probes for representativeness.

Vulnerability of sampling lines to condensation:

Equipment protection (from animals, workers):

Barn design and management typical of industry?

Maintenance

	Interval, d	Most recent	Notes
Clean PM10 head			
TEOM filter replacement			
Replace gas sampling membrane filters			At odor sampling
Clean TEOM air inlet			
Replace in-line filter			

Weather data

Temperature Yes _____ No _______
Humidity Yes _____ No _______
Wind velocity Yes _____ No _______
Wind direction Yes _____ No _______
Solar radiation Yes _____ No _______
Height of wind sensor: ________ m

Fan airflow measurements

Description of fan monitoring method:

Speed/airflow of variable speed fans?

Connections verified?

FANS measurements of fan curves:
Date(s):
Replications each point:
Number of static pressures:
Number of fans tested:
Notes:

Appendix F: Standard Operating Procedures

1. Information for Collaborating Producer
2. Gas Sampling System
3. Chemiluminescence Ammonia Analyzer
4. Open
5. Carbon Dioxide Analyzer
6. Real-time PM_{10} Monitor
7. Humidity and Temperature Measurements
8. Open
9. Wind Anemometry
10. Differential Static Pressure Transmitters
11. Ventilation Fan Monitoring
12. Open
13. Data Acquisition
14. Open
15. Open
16. Gravimetric TSP Samplers
17. Open
18. Manure Sampling
19. Manure Evaluation
20. Data Management
21. Fans Analyzer
22. Instrument Shelter
23. Weather Measurements

SOP 1. Information for Collaborating Producer

Project Description

The purpose of this project is to measure barns emissions of ammonia and dust and to test methods to reduce the emissions from the barns.

Measurements Taken

1. Inside and outside temperature and relative humidity.
2. Fan status (on/off) and airflow rate.
3. Operation of lights, feeders, and manure belts.
4. Static pressure difference between inside and outside the barn.
5. Inside and outside ammonia and carbon dioxide concentrations.
6. Exhaust and outside dust concentration.
7. On-site wind speed and direction.
8. Bird activity.

Measurement Duration

Continuous monitoring of two (2) barns for six (6) months, beginning August 2004. Some short-term measurements will be taken in later spring.

Measurement Logistics

Gas samples will be collected using flexible tubes, at six or seven locations in each barn. All gas samples and instrumentation equipment will be housed in an 8 ft x 24 ft contractor trailer positioned adjacent to the barns. This trailer will serve as a shelter for measurement instruments.

After the project is set up, University project staff will need to visit the site an estimated 3 times per week. This will be required to check equipment status, calibrate sensors, and to make sure everything is working as planned. Most all of this time will be spent in the instrumentation trailer and not the barns, although some time will need to be spent in the barns to change gas-line filters and to check sensors. Strict adherence to biosecurity as dictated by the producer will be followed.

Barn Modifications

In order to introduce the sensor wires and gas sampling lines into the barns, a sampling PVC chase of approximately four (4) inches in diameter will need to be introduced from the instrumentation shelter to each barn. This will require an access hole to be constructed to a small portion of one side-wall in each barn. This access hole will be sealed tight to not allow infiltration air from entering.

Requirements

The collaborating producer is requested to provide the university the following information about each barn, if possible:

Animal diet, feed consumption, inventory and average weight.
Production outputs, eggs, marketed animals or birds.
Record of manure removals (for indoor manure storage)
Record of cleaning operations.
Record of animal movements in and out of the barn
Record of water consumption.
Advance notification of any alteration in production schedules and methods.
Record of equipment failures, e.g. ventilation fans, inlet control, manure belts, etc.

Assurances
In any discussions of the results, there will be no reference to the participating producer involved unless expressly permitted. Complete anonymity will be strictly adhered to.

Questions and Answers for Producer

1. Q: Will you be cutting any holes in my barns?
   A: We need to run lines of Teflon tubing and control wiring into each barn (previously mentioned), and we will do our best to avoid disrupting the barn or its systems.

2. Q: How will you ensure you or your people won't bring any diseases onto our farms?
   A: We will follow your, or your company's, biosecurity protocols. At the very least, we'll disinfect vehicles we drive onto the farm according to your method, wear boots while we are at the farm or in barns, and make sure no one who comes onto your farm has been out of the country in the past 14 days or on another poultry or livestock farm in the past 24 hours.

   Q: Can we have access to the data and be able to use it?
   A: Absolutely. We can give you data summaries as you wish, and even give you access to the trailer if you will be very careful (we might find ourselves in situations where the producer could help us with a problem inside the trailer). Some of the data, like temperature, ammonia, and static pressure across fans, can help in managing the barns, and we'd like to learn more about how you can use it.

SOP 2. Gas Sampling System

An array of 3-way solenoid valves (#1-#13) in a gas sampling system (GSS) located in the instrument shelter and in the manure reaction laboratory will allow semi-continuous measurements of gas concentrations by automatic sequential gas sampling through 3 to 120-m long, heated Teflon tubes (6.4 mm ID) at 4-7 L/min from multiple locations, Figure 2.

A 47-mm dia., in-line Teflon PFA filter holder housing a 47-mm dia., Teflon PTFE-laminated polypropylene membrane filter with 1.0-µm pore size will be installed at the sampling end of each gas sampling tube to remove airborne particulate from the sampled air. In the barns, the filters will be changed at least biweekly and when filter loading is excessive as indicated by under pressure monitoring in manifold M2 with a bidirectional, 35,000-Pa differential static pressure sensor (Model 230, Setra, Inc., Boxborough, MA 01719-1304), Figure 2.

The selected gas stream will flow from the sample inlet via Teflon tubes through a 3-way Teflon-lined solenoid valve, a Teflon manifold (M2), a Teflon bag sampling port, a Teflon-lined diaphragm pump (P2), a stainless-steel lined 0-10 L/min mass flow meter (MFM) and a Teflon sampling manifold (M3), Figure 1. The internal pumps of the gas analyzers will draw air from manifold M3. Pumps are not required in the manure additive test because the air flows through the GSS under positive pressure.

A vacuum pump (P1) will draw air from a selected sampling location via solenoids and a Teflon manifold (M2), and transport the air stream to another Teflon manifold (M3), which connects to each gas analyzer with a short (< 3 m) 1/8" i.d. and 1/4" o.d. Teflon tube. The wetted surface of P1 is coated with Teflon PTFE. Internal and external pumps of all connected gas analyzers will draw air from M3. All air stream connections between M2 and the solenoids will be short 1/4" i.d. and 3/8" o.d. Teflon tubing.

Bypass pump P1 will draw air continuously from all inactive (unsampled) sampling tubes via 3-way solenoid valves and manifold M1 at about 1.0 L/min per tube (for 11 tubes). Bypass pumping will reduce the response time of the gas analysis by at least the residence time in the tubes, e.g. 38 s for a 100 m long tube at 5 L/min.

Sampling probes

Heated sampling tubes will be used to prevent condensation. Self-regulating heat trace will be controlled by LabView data acquisition program and a backup thermostat, Figure 1.

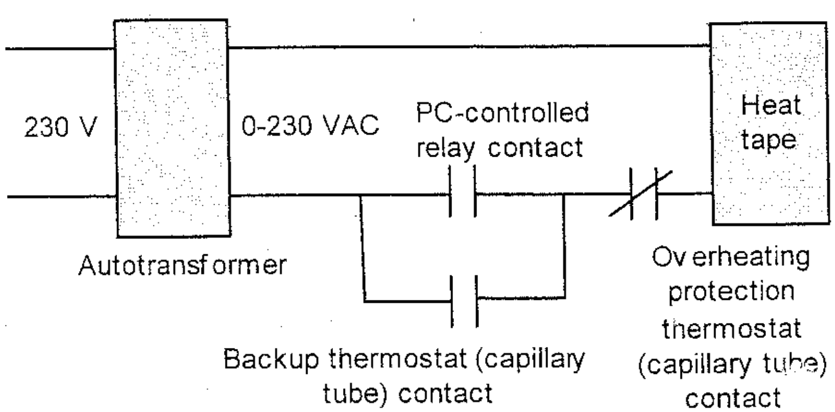


Figure 1. Heating control circuit for maintaining temperatures of air sampling lines above dew point (Heber et al., 2001).

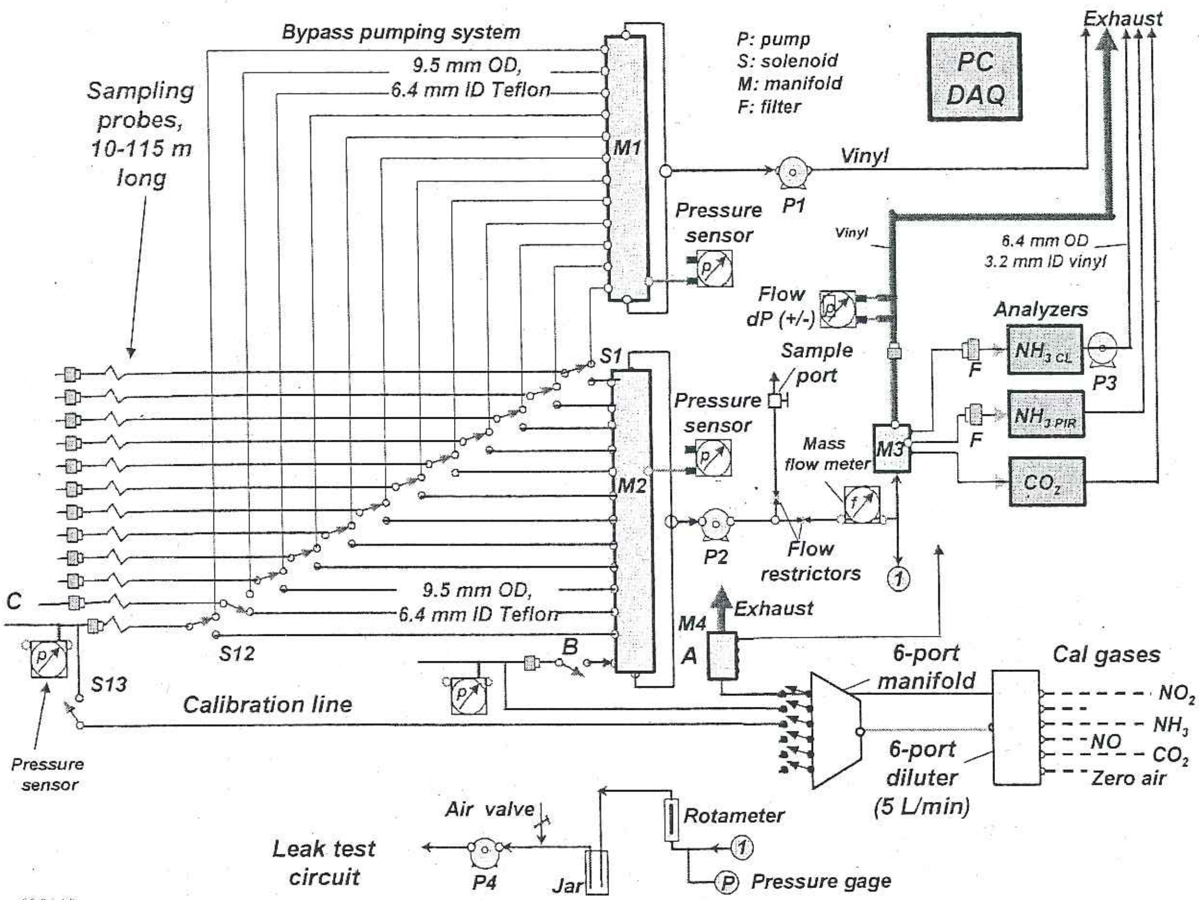


Figure 2. Schematic of instrument configuration. Note: F, Teflon filter (also installed at all sampling locations); the CO2 analyzer has internal pumps and internal filters.

SOP 3
Chemiluminescence Ammonia analyzer

Description and Principle of Operation

The chemiluminescence NH_3 analyzer (Model 17C, Thermal Environmental Instruments (TEI), Franklin, MA) is a combination NH_3 converter and an NO-NO_2-NO_x analyzer. The air sample containing ammonia is pulled into the analyzer using an external vacuum pump. The ammonia in the air sample is oxidized to nitric oxide (NO) with a stainless steel catalytic converter at 825°C. The NO is further oxidized with ozone (O_3) in the analyzer's reaction chamber producing nitrogen dioxide (NO_2) in an excited state that emit radiation as they return to a lower energy state (Equation 1). The intensity of the emitted radiation is proportional to concentration of NO.

$$NO + O_3 \rightarrow NO_2 + O_2 + hv \quad (1)$$

where O_2 is oxygen and hv represents photons, particles of light energy, or radiation energy that is generated by NO_2 in an excited state returning to the ground state. The emitted radiation is detected by a photomultiplier tube (PMT), which in turn generates an electronic signal that is processed into a gas concentration reading. Sample air is drawn at a flow rate of 0.6 L/min from the converter into the NH_3 analyzer through a particulate filter, a glass capillary, and a solenoid valve. The solenoid valve routes the sample either directly into the reaction chamber (NO mode), through the molybdemum converter at 325°C and the reaction chamber (NO_x mode), or through the stainless steel catalytic converter and the reaction chamber (N_t mode). The NH_3 analyzer's full scale is adjustable up to 200 ppm. It has a lower detectable limit of 1 ppb. Its precision is 0.5% of full scale and the 0 to 90% response time is 120 s with 10 s averaging (TEI *Model 17C Chemiluminescence NH_3 Analyzer Instruction Manual*). Ammonia concentration is calculated based on the difference between the readings obtained by the N_t and NO_x modes. The response time of the instrument is decreased if operated only in the N_t mode.

Calibration

Calibration Gases

Zero air, nitric oxide (NO) in N2 and NH_3 in air are used to calibrate the instrument. However, if the instrument is operated only in the N_t mode, then NO is needed only to periodically assess the need to maintain the converter by testing its efficiency. The certified calibration gases will consist of zero air (Acid Rain CEM zero), NO in nitrogen (EPA Protocol, ±2% accuracy), NH_3 in nitrogen (Title 5 ammonia per EPA Conditional Method 27E, ±3% accuracy). Recommended Vendor: Scott Specialty Gases, 868 Sivert Drive, Wood Dale, IL 60191 Phone: (630) 860-1824

Manual Zero and Span Check Procedure for Analyzer Only

- Record calibration date and time in the lab notebook.
- Detach the NH_3 inlet tube including the filter from the existing sampling manifold. Close the pipe adapter of the sampling manifold with a cap or plug.
- Attach the NH_3 analyzer inlet tube including the filter to a calibration manifold.

Zero Gas Check

1. Close regulator valve on the zero gas cylinder
2. Open main valve on zero gas cylinder
3. Insert the 1/8" ID tubing (from the gas cylinder) into the calibration manifold connected to the valve; then open the regulator valve to allow gas flow. Zero gas is now flowing from the cylinder to the analyzers
4. Adjust regulator valve until vent airflow is about 1 L/min (read from bottom of ball of the vent monitoring flow meter installed in outlet of calibration manifold). This provide a little extra zero air to the analyzers and keep the pressure inside the manifold close to the atmospheric pressure.
5. Record time and analyzer display in lab notebook after display is stabilized (typically 5 to 10 minutes).
6. Press **MENU** button on the NH_3 Analyzer
   a. Select *calibration* press **ENTER**
   b. Select *calibrate zero* press **ENTER**
   c. When reading is stable, press **ENTER** to zero the analyzer
   d. Press **RUN**
7. Close regulator and remove tubing from zero gas cylinder.

Span Gas Check (NO)

1) Close regulator valve on span gas cylinder
2) Open main valve on span gas cylinder
3) Insert 1/8" ID tubing (from the gas cylinder) into the calibration manifold connected to the valve; then open the regulator valve to allow gas flow
4) Adjust regulator valve until calibration manifold exhaust airflow is 1 L/min (read from bottom of ball of the flow meter).
5) Record the time and analyzer display on the lab notebook after display is stabilized (typically 5 to 10 minutes).
6) Press **MENU** on the NH_3 Analyzer
   a. Select *calibration* press **ENTER**
   b. Select *NO* press **ENTER**
   c. Set *NO* value to the certified concentration of the calibration gas
   d. When readings are stable press **ENTER**
   e. Press **RUN**
7) Close regulator and remove tubing from gas cylinder

Span Gas Check (NH_3)

1) Close regulator valve on span gas cylinder
2) Open main valve on span NH_3 cylinder
3) Insert 1/8" ID tubing (from the gas cylinder) into the calibration manifold connected to the valve; then open regulator valve to allow gas flow
4) Adjust regulator valve until gas flow is 1 L/min (read from bottom of ball of the flow meter).

5) Record the time and analyzer display on the lab notebook after display is stabilized (typically 5 to 10 minutes).
6) Press **MENU** on the NH_3 Analyzer
    a. Select *calibration* press **ENTER**
    b. Select *NH_3* press **ENTER**
    c. Set NH_3 value to concentration of the calibration gas
    d. When readings are stable press **ENTER**
    e. Press **RUN**
7) Close regulator and remove tubing from gas cylinder

Post Calibration

Reattach the filters to the existing gas sampling system.
Check and close main valves on all cylinders.
Calibration of the NH_3 analyzer is complete

List of Spare Parts

Description	**Part Number**
Ammonia Scrubber	10157
Capillary	4121
Ozone Capillary	4119
O-ring for Capillary	4800
Stainless Steel Converter Cartridge	10155
Thermocouple	10170
Fuse - 5 amp	4523
Solenoid Valve	8119
Moly Converter Cartridge	9269
Thermocouple - Moly	9204
Bandheater - Moly (110 volt)	9261
Pump (See below)	9456
Pump repair kit	9464
Fuse - 3 amp slo-blo	4510

Vacuum Pump (TEI p/n 9456): KNF Double-Headed Vacuum Pump (PU 425-NO26.3-8.90)
KNF Neuberger
2 Black Forest Road
Trenton, NJ 08691
609-890-8600

Vacuum Pump (alternative less expensive)
Pump needs to provide 29 inches of mercury dead head
Part No. LAA-V104-NQ
Clean Air Engineering, 500 W. Wood Street, Palatine, IL 60067, 1-800-553-5511 ext. 2222
Vacuum Pump repair kit # K425 9XTP ($41 from KNF Neuberger)

Manufacturer Contact Information

Thermo Environmental Instruments (www.thermoei.com)
8 West Forge Parkway
Franklin, MA 02038
Tel: (508) 520-0430 ext. 6812
Fax: (508) 520-1460
Service: Barry Pepin, Service Engineer, e6908, E-Mail: Bpepin@thermoei.com

Calibration Record Sheet for TEI Model 17 Ammonia Analyzer

Date of Calibration: ________________ Calibrated by: ________________

Time	Items	Unit =	Notes
: :	Vacuum pressure, (mm Hg)		
	Ozonator airflow (L/min)		
	Sample airflow (L/min)		
: :	Zero air applied	---	Cylinder P: ___ psi
: :	Time switch on	---	
: :	Nt Reading (☐ PC, ☐ Analyzer)		
: :	Nt Reading (☐ PC, ☐ Analyzer)		
: :	Reset to zero gas	Yes/No	
: :	NO (______ ppm) applied	---	Cylinder P: ___ psi
: :	Nt Reading (☐ PC, ☐ Analyzer)		
: :	Nt Reading (☐ PC, ☐ Analyzer)		
: :	Reset to span gas	Yes/No	
---	New coefficient		
: :	NH_3 (______ ppm) applied	---	Cylinder P: ___ psi
: :	Nt Reading (☐ PC, ☐ Analyzer)		
: :	Nt Reading (☐ PC, ☐ Analyzer)		
: :	Reset to span gas	Yes/No	
---	New coefficient		
: :	New coefficient saved	Yes/No	
: :	Time switch off (5 min/10 min)	---	
: :	Connect analyzer back to sampling system.		

Note:

SOP 5. Carbon Dioxide Analyzer

Carbon dioxide analyzers (Model 3600, Mine Safety Appliances, Co., Pittsburgh, PA) will be utilized in each mobile lab and in the manure additive test.

Calibration Gases

Zero air and carbon dioxide (CO_2) in N2 will be used in the calibrations.

Calibration Procedure

Record the calibration date and time on the lab notebook.
Detach the CO_2 inlet from the sampling manifold of the CEM. Close the pipe adapter in the sampling manifold with a cap.
Attach the CO_2 inlet to the manifold of the calibration loop.

Zero Gas Check

1) Close regulator valve on the zero gas cylinder
2) Open main valve on zero gas cylinder
3) Insert the 1/8" ID tubing (from the gas cylinder) into the calibration manifold then open the regulator valve to allow gas flow
4) Adjust regulator valve until airflow is 1 L/min (read from bottom of ball of the flow meter). This provide a little extra aero air to the analyzers and keep the pressure inside the manifold close to the atmospheric pressure
5) Wait for 5 to 10 minutes for the display to stabilize, record the time and analyzer display on the lab notebook
6) If the stabilized reading is > 50 or <-50 ppm CO_2, open the front door of the CO_2 Analyzer and adjust the "zero" screw to zero the concentration display
7) Close the regulator and remove tubing from zero gas cylinder

Span Gas Check (CO2)

1) Close regulator valve on the span gas cylinder
2) Open main valve on span gas cylinder
3) Insert the 1/8" ID tubing (from the gas cylinder) into the calibration manifold then open the regulator valve to allow gas flow
4) Adjust regulator valve until airflow is 1 L/min (read from bottom of ball of the flow meter).
5) Read CO_2 concentration displayed on the computer screen. Wait for about 5 to 10 minutes for the display to stabilize. Record the time and analyzer display on the lab notebook

6) If the stabilized reading is > 50 or <50 ppm of the calibration CO_2, open the front door of the CO_2 Analyzer and adjust the "span" screw and make the concentration display equal to the concentration of the calibration gas.
7) Close the regulator and remove tubing from zero gas cylinder

Post Calibration

Reattach the filter to the gas sampling system.
Check and close main valves on all cylinders
Calibration of the CO_2 analyzer is complete

Calibration Record Sheet for Carbon Dioxide Analyzer

Date of Calibration: ________________ Calibrated by: ________________

Time	Items	#230	#228	Notes
: :	Zero air applied	---	---	Cylinder P: _____ psi
: :	Reading (☐ PC, ☐ Analyzer)			
: :	Reading (☐ PC, ☐ Analyzer)			
: :	Reset to zero gas	Yes/No	Yes/No	
: :	CO_2 (___ ppm) applied	---	---	Cylinder P: _____ psi
: :	Reading (☐ PC, ☐ Analyzer)			
: :	Reading (☐ PC, ☐ Analyzer)			
: :	Reset to span gas	Yes/No	Yes/No	
: :	Connect analyzers back to the CEM system.			

SOP 6. Real-time PM10 Monitor

Introduction

The TEOM instrument (TEOM 1400a Ambient Particulate (PM-10) Monitor) is a continuous PM monitoring device designated by USEPA as an equivalent method (EPA Designation No. EQPM-1090-079) for PM_{10} (10 microns sized particles and under) and used extensively in state and national $PM_{2.5}$ monitoring networks. The acronym TEOM stands for "Tapered Element Oscillating Microbalance," an inertial measurement technique that operates on changes in the resonant frequency of an oscillating element as a function of increases in particle mass collected on a filter attached to the element. Changes in the element's resonant frequency are sampled electronically in quasi-real time, providing both continuous and time-averaged measures of mass accumulation that are directly proportional to instantaneous and time-averaged mass concentrations in air, respectively. The device operates at an industry-standard, volume-controlled flow rate of 16.7 L/min so that it can be outfitted with a variety of commercially available pre-separator inlets suitable for measuring PM_{10}, $PM_{2.5}$ or any other size fraction of interest.

Switching Instrument on/off

Since the airflow is maintained at a constant volume, corrected for local temperature and barometric pressure, the operation of this monitor requires that the temperature and pressure sensors are connected for proper temperature and pressure readings and flow corrections.

Turn on unit

Supply power to the instrument by plugging in the power cord to 120 VAC, and pressing the power button on the front panel of the TEOM control unit. The main screen (four-line display) will soon appear after showing the name of the instrument. Turn on the pump to draw the sample streams by plugging in the power cord to 120 VAC. The monitor waits at least 30 min after being powered up to compute the first mass concentration data.

Turn off unit

Press the power button on the front panel of the TEOM control unit. The four-line display becomes blank. Turn off the vacuum pump by pressing the power button and disconnect the control unit from 120 VAC by unplugging the power cord.

Status Line on Main Screen

Whenever a status code other then "OK" is shown on the display, the instrument automatically turns on the "Check Status" light on the front of the control unit. The information displayed on the main screen includes status condition, operating mode, A/O 1 mode, RS-232 mode, protection, and time. For example, the screen will show the following line at 8:11 AM:

OK	4+	51%	NU	08:11

Status condition

OK Normal operation
M No frequency signal
T Temperature(s) outside of operational bounds
F Flow(s) outside of operational bounds
X Filter nearing capacity—exchange filter

Operating mode

Temperature/flow stabilization
Begin TM computation
TM computed, begin MR/MC computation
Normal operating mode
S Set up mode
X Stop all mode

A/O 1 mode

(Blank) Analog output 1 normal definition
\+ Analog output 1 used for status watch

XX% Filter loading (percent)

RS-232 mode

N None
P Print online
R R&P protocol
A AK protocol
G German network protocol
S Storage to printer
F Fast storage output

Protection

U Unlocked
L Low lock
H High lock

XX:XX Current time (24-hr format)

Using the Keypads and Software

User should refer to Section 4.5 of the operating manual and become familiar with the incorporated menu-driven software and keypads.

Filter Storage and Exchange

The measurements must be conducted with TEOM filter cartridges that are made of Teflon-coated glass fiber filter paper. Filters should be stored inside the sensor unit for easy access and to keep them dry and warm. Do not handle new filter with your fingers. Instead, use the filter exchange tool and follow the procedures given in the operating manual. Keep the sample pump running to facilitate filter exchange. Use the two pockets on the right side of the mass transducer (inside) to store the next two new TEOM filters, for pre-conditioning and removal of excessive moisture build-up prior to use.

System Operation after Power Failure

The system resets itself when power is regained, and enters the same RS-232 mode as before. All operating parameters are maintained in the system's battery backed-up CMOS memory.

Internal Data Logging

Values logged internally are stored in a circular buffer, and can be viewed from the control unit (press <Store>, and select "View Storage", or enter 08<Enter> from any screen), or downloaded over the monitor's RS-232 port. The instrument always stores the time, date, and station number in each record in addition to the data fields selected by the user. The storage capacity is given in Fig. 4-11 of the operating manual, generally about 1.7 weeks of 8 data fields per record, using a storage interval of 10 minutes.

Setting Variables Stored in Data Logger

The <Step Screen> key toggles the instrument between the View Storage Screen and Set Storage Screen, or, pressing 09<Enter> can gain direct access to the Set Storage Screen from any screen. The first eight lines of the Set Storage Screen contain the titles of the variables currently being stored in the data logger (Program Register Codes listed in Appendix A of operating manual). The "Interval" variable defines the time (in seconds) between successive writings of data to the circular buffer.

Some popular program register codes:

Code	Variable	Units
008	Mass concentration	$\mu g/m^3$
009	Total mass	μg
035	Filter loading	%
039	Current main flow	L/min
040	Current auxiliary flow	L/min
041	Status condition	code
057	30-min average mass concentration	$\mu g/m^3$
130	Current ambient temperature	^oC
131	Current ambient pressure	atm

Setting Analog Outputs

The instrument's three analog output channels are accessible from the identical 15-pin connectors on the front and back panels of the control unit. Details regarding the pin assignments and voltage (VDC) of outputs are given in the operating manual (Section 5.1). To bring up the Set Analog Output Screen, press <A/O>, or select "Set Analog Output" from Menu Screen, or press 04<Enter>.

Downloading Stored Data into Computer

Connect an IBM AT-compatible computer to an RS-232 port using the provided 9-to-9 pin computer cable. Make sure the computer is logged to the proper directory and subdirectory for program execution. Type TEOMCOMM <Enter> to bring up the software. Use the "Download storage" command to download the stored data in the data logger. Ensure that the communication software is set for the same communication parameters as the instrument.

Other Serial Output and Two-Way Communications

Details of serial outputs and two-way communications (such as online printing and connecting to a computer through a modem) are given in section 6 of the operating manual.

Nomenclature

TEOM	Tapered element oscillating microbalance
TM	Total mass
MR	Mass rate
MC	Mass concentration
AK	AK protocol was developed by the German automobile industry to standardize thecommunication among instrumentation. This protocol is used in combination with the TEOMCOMM software for data logging of the system.
A/O	Analog output
atm	atmosphere, 746 mBar

Calibration

Procedures are based on routine flow auditing, leak checking, and mass calibration verification. Since the TEOM monitor can be directly mass calibrated, it can be directly quality assured using a mass standard. All QA procedures should be coordinated with routine maintenance procedures to minimize down time.

<u>Flow Audit</u>

A flow audit adapter is provided and the procedures are outlined in the operating manual. Both the sample flow rate and total flow rate may be checked using the flow audit adapter with a capped nut for closing the flow splitter bypass line port. It is recommended that the volumetric flow rates be within ±7% of the set points. The United States Environmental

Protection Agency (USEPA) requires a tolerance of ±10% for the total flow through the PM-10 inlet. If measured flows differ by more than the stated tolerances, recheck all settings, and perform the test again. Large errors in the flow may indicate other sources of error, such as a malfunctioning flow controller, a system leak, or improper temperature and pressure settings.

Leak Check

The leak check procedures are included in the operating manual (Section 7.6). The leak check should be performed with NO sample filter attached to the mass transducer, which will prevent accidental damage from occurring to the sample filter cartridge when exposed to the high pressure drop (vacuum) in the sample line that the leak check creates. Flow rates should indicate less than 0.15 L/min for the main flow and less than 0.65 L/min for the auxiliary flow with the end of the sample line closed, if not, systematically check plumbing for connector leaks.

Mass Calibration Verification

The mass transducer is permanently calibrated and never requires recalibration under normal use. However, the mass measurement accuracy of the instrument may be verified following procedures in the operating manual. R&P offers a mass calibration verification kit to help perform this procedure.

Maintenance

The lifetime of a **TEOM filter cartridge** depends on the nature and concentration of the particulate sampled, and the main flow rate setting (1, 2, or 3 l/min). The filter must be exchanged when the filter loading value (as shown on the status line of the main menu) **approaches 100%.** At a flow rate of 3 l/min, 100% filter loading generally corresponds to a total mass accumulation of approximately 3 to 5 mg of particulate. Filter lifetime at a main flow rate of 3 l/min is generally 21 days at an average PM-10 concentration of 50 $\mu g/m^3$. Flow splitter adapters for 1 and 2 l/min operation are available for use in areas with higher particulate concentrations.

The factory recommended schedule of periodic maintenance and the schedule to be adopted for use in livestock barns are as follows:

Maintenance item	Factory	This Project
Clean external screen	-	As necessary
Clean PM-10 inlet	Upon filter exchange	Weekly
Exchange in-line filters	6 mon. or when loaded	When loaded
Clean air inlet system	6 mon.	Monthly
Leak test	Annually	Bimonthly
Mass flow controller calibration	Annually	Bimonthly
Analog board calibration	Annually	Every 5 months
Mass calibration verification	Annually	Bimonthly

The PM10 inlet requires regular maintenance in livestock barns. A wire-mesh external screen was designed for the PM10 inlet to keep large dust particles out. This external screen requires cleaning every two to three days, depending on PM concentration in the air. Cleaning is accomplished by carefully removing the external screen, and, in an area downwind of the inlet unit, brushing it or cleaning with water and letting dry. After all visible dust has been removed from the external screen, carefully replace it on the PM10 head, so as not to disturb the sensor unit.

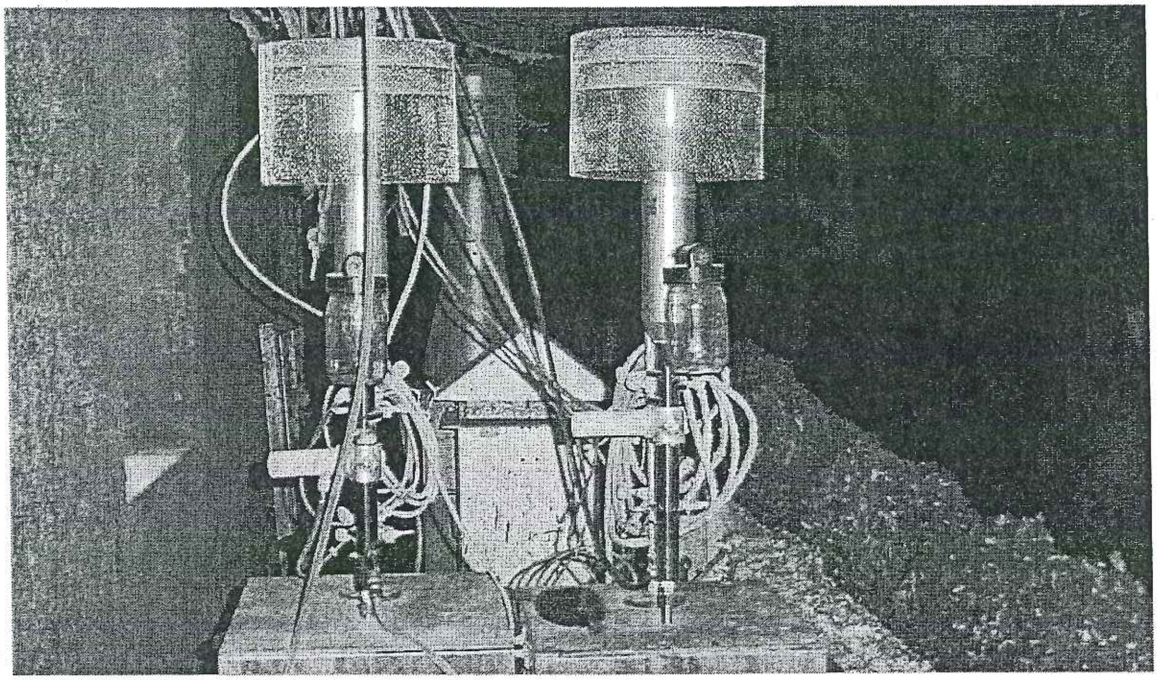


Figure. TEOM PM10 inlets with external screens. (Source: Purdue University)

The PM_{10} inlet itself should be cleaned weekly. In order to do this one must first push the <Data Stop> button on the keypad. Remove the PM_{10} inlet and replace it with an in-line filter to prevent excessive amounts of dust being pulled into the TEOM unit. At this point, unscrew the Acceleration Assembly from the Collector Assembly (see fig. F-1). Using a can of pressurized Dust Remover (found at most hardware and electronics retailers), spray the inlet screen on the Acceleration Assembly until clean. Then spray the inside of the Acceleration Assembly from the bottom tube. This should remove most of the dust from the screen. Also spray the internal areas of the Collector Assembly. After these have been cleaned, feel the o-rings, located on the lower part of the Acceleration Assembly and on the lower part of the Collector Assembly, for the presence of silicon grease. Grease as needed to maintain a slight layer of Silicon Grease. Carefully replace the inlet unit, and return to the control unit of the TEOM system, and press the <Data Stop> button once more. This will prevent skewed data from being recorded. It will automatically begin recording in approximately 30 min.

<u>Other Settings</u>

Flow rate through sample inlet	16.7 L/min (1 m^3/hr)
Main flow rate	3 L/min
Temperature of sample stream	50 ^oC

Particulate concentration	< 5 μg/m^3 to several g/m^3
Standard Conditions	1 atm pressure, 20°C

Spare Parts and Consumables

Slow blow 2A, 250 V fuse
2A $ 250 V in-line fuse, P/N 04003419
Box of 20 TEOM filter cartridges (TX40 media), P/N 57-000397-0020
Large bypass in-line filter, P/N 57-002758
Flow controller filter, P/N 30-003097

Manufacturer Contact Information

Rupprecht & Patashnick Co., Inc.
25 Corporate Circle
Albany, NY 12203

Timothy Morphy
Assistant Product Manager
518.452.0065 voice
518.452.0067 fax
tmorphy@rpco.com (email)

Peggy O'Gormon
Marketing Associate
X3229, email: pogorman@rpco2.com

SOP 7. Humidity and Temperature Measurements

HMW61Y Humidity Transmitter

Electrical Cable Connection

+RH	-RH		+T	-T
O	O	O	O	O
Red	White	Black	Orange	Blue

Measurement Instructions

The probe of the transmitter should always point downwards when installed.

Supply voltage: 10 … 35 VDC (RL = 0 Ω)
20 … 35 VDC (RL = 500 Ω)
RH range: 0 …100% (Output 4…20mA)
T range: -20°C … +80°C (Output 4…20mA)

Temperature (°C)	-20	-10	0	10	20	30	40	50	60	70	80
Output (mA)	4	5.6	7.2	8.8	10.4	12	13.6	15.2	16.8	18.4	20

Reference

HMW61U/Y Humidity Transmitter Operating Manual, March 2000.

HMK15 Humidity Calibrator

Introduction

The functioning of the HMK15 is based on the fact that certain salt solutions generate a certain relative humidity in the air above them. The salt solutions suitable for the HMK15 calibrator are e.g. lithium chloride LiCl (11% RH), magnesium chloride $MgCl_2$ (33% RH), sodium chloride NaCl (75% RH) and potassium sulphate K_2SO_4 (97% RH). For calibration, the sensor head is inserted into a salt chamber containing a saturated salt solution. The probe/transmitter reading is then adjusted to the correct value. Calibration is usually performed at least at two different humidities to ensure the sensor accuracy over the entire humidity range (0-100 % RH).

Description of the solutions

Salt Name	RH	Usage
LiCl	11%	Used as the dry end reference
$MgCl_2$	33%	Used as a check point if calibration is performed at more than two points.
NaCl	75%	Used as the wet end reference for probes measuring in applications with normal humidities.
K_2SO_4	97%	Used as the wet end reference for probes measuring in applications with very high humidities.

NOTE: **Never add water to dry LiCl salt.**
LiCl is harmful when swallowed; the solution is also corrosive.
If the LiCl solution is used or stored in temperatures below +18 C, its equilibrium humidity changes permanently.

Solution Preparation Procedure

Take the calibrator out of the box. Open the transit cover of the chamber. Remove the measurement cover from the chamber holder and press the transit cover on the holder.

Pour ion exchanged water into the chamber; the required amounts are given below:

LiCl	14 ml of water
$MgCl_2$	3 ml of water
NaCl	10 ml of water
K_2SO_4	10 ml of water

Sprinkle the contents of a salt package in small quantities into the chamber, stirring constantly. When measuring with the measurement cup, make sure that the cup is clean and dry. Rinse and dry the cup after every use.

LiCl	15 g or 18 ml
$MgCl_2$	30 g or 30 ml
NaCl	20 g or 15 ml
K_2SO_4	30 g or 20 ml

When all salt has been sprinkled into the chamber, the saturated salt solution should have the ratio of 60-90% undissolved salt to 10-40% liquid.

Close the chamber with the chamber cover. Fasten the salt chamber on the base plate and close the measurement holes with rubber plugs. Make sure that chamber covers and plugs are carefully closed.

Write the preparation date on a sticker and mark the chamber with it.

Allow approximately 24 hours for stabilization before use.

SOP 7. Humidity and Temperature Measurements

HMW61Y Humidity Transmitter

Electrical Cable Connection

+RH	-RH		+T	-T
O	O	O	O	O
Red	White	Black	Orange	Blue

Measurement Instructions

The probe of the transmitter should always point downwards when installed.

Supply voltage:	10 … 35 VDC (RL = 0 Ω)
	20 … 35 VDC (RL = 500 Ω)
RH range:	0 …100% (Output 4…20mA)
T range:	-20°C … +80°C (Output 4…20mA)

Temperature (°C)	-20	-10	0	10	20	30	40	50	60	70	80
Output (mA)	4	5.6	7.2	8.8	10.4	12	13.6	15.2	16.8	18.4	20

Reference

HMW61U/Y Humidity Transmitter Operating Manual, March 2000.

HMK15 Humidity Calibrator

Introduction

The functioning of the HMK15 is based on the fact that certain salt solutions generate a certain relative humidity in the air above them. The salt solutions suitable for the HMK15 calibrator are e.g. lithium chloride LiCl (11% RH), magnesium chloride $MgCl_2$ (33% RH), sodium chloride NaCl (75% RH) and potassium sulphate K_2SO_4 (97% RH). For calibration, the sensor head is inserted into a salt chamber containing a saturated salt solution. The probe/transmitter reading is then adjusted to the correct value. Calibration is usually performed at least at two different humidities to ensure the sensor accuracy over the entire humidity range (0-100 % RH).

Description of the solutions

Salt Name	RH	Usage
LiCl	11%	Used as the dry end reference
$MgCl_2$	33%	Used as a check point if calibration is performed at more than two points.
NaCl	75%	Used as the wet end reference for probes measuring in applications with normal humidities.
K_2SO_4	97%	Used as the wet end reference for probes measuring in applications with very high humidities.

NOTE: **Never add water to dry LiCl salt.**
LiCl is harmful when swallowed; the solution is also corrosive.
If the LiCl solution is used or stored in temperatures below +18 C, its equilibrium humidity changes permanently.

Solution Preparation Procedure

Take the calibrator out of the box. Open the transit cover of the chamber. Remove the measurement cover from the chamber holder and press the transit cover on the holder.

Pour ion exchanged water into the chamber; the required amounts are given below:

LiCl	14 ml of water
$MgCl_2$	3 ml of water
NaCl	10 ml of water
K_2SO_4	10 ml of water

Sprinkle the contents of a salt package in small quantities into the chamber, stirring constantly. When measuring with the measurement cup, make sure that the cup is clean and dry. Rinse and dry the cup after every use.

LiCl	15 g or 18 ml
$MgCl_2$	30 g or 30 ml
NaCl	20 g or 15 ml
K_2SO_4	30 g or 20 ml

When all salt has been sprinkled into the chamber, the saturated salt solution should have the ratio of 60-90% undissolved salt to 10-40% liquid.

Close the chamber with the chamber cover. Fasten the salt chamber on the base plate and close the measurement holes with rubber plugs. Make sure that chamber covers and plugs are carefully closed.

Write the preparation date on a sticker and mark the chamber with it.

Allow approximately 24 hours for stabilization before use.

Notices for Avoiding Errors Introduced by Temperature Difference

Usually, the errors during humidity calibration are due to temperature differences. In laboratory, the calibrator should be stored in that part of the room where the temperature at most stable and must be kept out of direct sunlight and away from localized heat sources.

Handle the probe as little as possible. Do not hold the salt chamber or other parts of the calibrator in your hand during calibration as they warm up and cause errors in the readings.

During calibration, the thermometer is inserted into the 13.5 mm hole of a salt chamber. Press it downwards until it passes the O-rings. The thermometer is correctly in place when you can feel a resistance while pressing it downwards.

When the thermometers are not in use or the calibrator is transformed from one place to another, place the thermometer in holders.

Calibration procedure

(If the probe/transmitter is checked against several humidity references, the checking must first be made at the dry end.)

1. Leave the HMK15 calibrator and the probe at the calibration site for at least 30 minutes before starting the calibration in order to let the probe temperature stabilize to the room temperature.
2. In the temperature range of 25-30 °C, lithium chloride humidity changes only very slightly, thus it is not necessary to use the thermometer. However, we may use it to ensure that the sleeve is in the correct place.
3. Take off the grid or filter protecting the sensor. Insert the probe into a suitable hole of the LiCl salt chamber. Press it downwards till it passes through the O-rings. Wait until the humidity reading stabilizes; this will take about 10-30 minutes. The shorter the time the hole stays open before inserting the probe; the shorter the stabilization time required.
4. Read the salt chamber temperature from the thermometer; then read the closest humidity value from the Greenspan's calibration table. Adjust the dry end to the correspond value given in the table.
5. Then use the NaCl as the wet reference. If calibrating probes that are being used for a long time in high humidities (90-100RH). Use the K_2SO_4 as the wet reference.
6. Then repeat step 4-6 for the wet reference. Note that in high humidities the risk for errors increases and the stabilization time should be longer (about 20-40 min).

Greenspan's calibration table

°C	LiCl	$MgCl_2$	NaCl	K_2SO_4
0	*	33.7±0.3	75.5±0.3	98.8±1.1
5	*	33.6±0.3	75.7±0.3	98.5±0.9
10	*	33.5±0.2	75.7±0.2	98.2±0.8
15	*	33.3±0.2	75.6±0.2	97.9±0.6
20	11.3±0.3	33.1±0.2	75.5±0.1	97.6±0.5
25	11.3±0.3	32.8±0.2	75.3±0.1	97.3±0.5
30	11.3±0.2	32.4±0.1	75.1±0.1	97.0±0.4
35	11.3±0.2	32.1±0.1	74.9±0.1	96.7±0.4
40	11.2±0.2	31.6±0.1	74.7±0.1	96.4±0.4
45	11.2±0.2	31.1±0.1	74.5±0.2	96.1±0.4
50	11.1±0.2	30.5±0.1	74.4±0.2	95.8±0.5

Transportation Instructions

1. Turn the protective sleeve on the thermometer and place the thermometer in the holder.
2. Replace chamber covers with transit covers. Press the chamber covers on vacant chamber holders for transportation.
3. During transportation, keep the chamber as upright as possible.
4. The closer the transportation temperature is to the temperature of the calibration site, the shorter the stabilization time will be. If the transportation is below 18°C, the LiCl should transport separately to keep the solution warm.
5. When the calibrator is at the calibration site, remove the transit covers and fasten the chamber covers on salt chambers.
6. Clean the transit covers with a damp cloth and press them on vacant chamber holders.
7. Repeat the calibration procedures.

Quality control

Depending on the frequency of use and the general operating conditions, the salt solutions should be replaced after about 6-12 months. A visual check should be performed at intervals of 2-3 months. There must be a minimum of approximately 10% of undissolved salt at the bottom of the chamber and the salt must be clean.

Note: LiCl may crystallize on the surface. But it may still have solution under the surface. In such case, stir the solution and check the next day.

For correct calibration, it is essential that salt chambers are tightly closed. Check the O-rings at each salt replacement. If they are damaged, replace with new ones.

Operating temperature range is 0-50°C.

Accuracy of salt solution humidities

Lithium chloride LiCl ±1.0%RH + Greenspan's uncertainty

Magnesium chloride $MgCl_2$	±1.0%RH + Greenspan's uncertainty
Sodium chloride NaCl	±1.4%RH + Greenspan's uncertainty
Potassium sulphate K_2SO_4	±1.5%RH + Greenspan's uncertainty

Accuracy of the thermometer

With mercury	±0.3°C
With red capillary liquid	±1°C

Reference

HMK15 Humidity Calibrator Operating Manual, June 1998.

HMI41 Indicator and HMP46 Probe

Operation Procedure

1. Turn the power on. If the screen shows "noProb", check if the probe is correctly installed.
2. After a few seconds, if the screen shows "Lo bat", then change the battery.
3. Relative humidity and temperature values will automatically shown after battery checking.
4. Press "MODE" to display the dewpoint temperature(Td).
5. Press "HOLD" to freeze the display the display the current reading. Then press "MODE" or "ENTER" to return to the normal mode.
6. Press "HOLD" under the HOLD-mode, then the minimum reading after power on will show.
7. Press "HOLD" under the MIN-mode will show the maximum reading. Then press any button to return to the normal mode.

Calibration Procedure

The calibration is not needed unless the adjustment has been changed. The probe must always be recalibrated when the sensor is changed.

A. Probe calibration with the trimmer potentiometer:

The potentiometer marked **"T" is for factory use only**. "D" is for the dry end, and "W" is for the wet end. Calibration can be performed with the HMK15.

1. Leave the HMK15 calibrator and the probe at the calibration site for at least 30 minutes to stabilize before starting the calibration.
2. Insert the probe into the measure hole of the LiCl solution. Wait until the humidity reading stabilizes, this will take about 10-30 minutes. Then use a suitable wrench to adjust the "D" of the trimmer potentiometer to the humidity value on the Greenspan's calibration table.

3. Then use the NaCl or K_2SO_4 as the wet reference depends on the humidity we need to use. If calibrating probes that are being used for a long time in high humidities (90-100RH), use the K_2SO_4. Otherwise, use the NaCl. Adjust the "W" of the trimmer potentiometer to the humidity value on the Greenspan's calibration table. (Note that in high humidities the risk for errors increases. Therefore the stabilization time should be longer (about 20-40 min).)

B. Calibration with HMI41 Software Commands:

This method is useful only when one probe is used, otherwise, we should use the probe potentiometers.

Data Collecting
Refer to page 20 of the manual.

Data transferring
Refer to page 26 of the manual.

Changing the settings
Refer to page 33 of the manual.

Reference

HMI41 Indicator and HMP41/45/46 Probes Operating Manual, March 1998.

Table 1. Maintenance log

Data	Operator	Reason (salt replacement or other maintenance)

Table 2. Salt solution checks

Data	Operator	LiCl	$MgCl_2$	NaCl	K_2SO_4

SOP 9 Wind Anemometry

Introduction

The R.M. Young Model 05103-5 Wind Monitor measures horizontal wind speed and direction. Propeller rotation produces an AC sine wave signal with frequency proportional to wind speed. Three complete sine waves are produced for each propeller rotation. Vane position in transmitted by a 10K Ω potentiometer. With a constant voltage applied to the potentiometer, the output signal is an analog voltage directly proportional to wind direction angle.

Installation

1. Connect instrument cable and connect to a recorder.
2. Choose a known reference wind direction on the horizon and point nose cone of the instrument to it.
3. While holding the vane in position, slowly turn base until recorder shows proper value. Then tight everything in position.

Calibration

Accurate wind direction calibration requires a Model 18112 vane angle bench stand. Wind speed calibration is determined by propeller pitch and the output of the transducer.

Specification Summary

	Range	Excited voltage	Output
Wind Speed	0-60 m/s (160 mph)	-	AC sine wave (3 cycles per rotation, 80 mV p-p 100rpm)
Wind Direction	360° mechanical, 355° electrical (5° open)	*15VDC max*	Analog DC voltage proportional to angle

Note

Young signal conditioning devices clamp the signal to excitation level.
Failure to properly ground the wind monitor will cause erroneous signals or transducer damage.
Terminal "EARTH GND" should be connected to the ground.

Reference

Model 05103-5 Wind Monitor Manual PN 05103-5-90, March 2002.

SOP 10. Differential Static Pressure

The purpose of differential pressure measurements is to monitor operation of the ventilation system and to aid in the calculation of fan airflow.

Barn static pressure will be monitored continuously in the barns near the exhaust fans. using a differential pressure transmitter (Setra Part No. 2671-100-L-B-11-9K-F-N) with a range of ±100 Pa and an accuracy of ±0.5 Pa. For large barns with fans on each sidewall, the differential static pressure across each sidewall should be measured. A common static pressure port is used inside the barn and the difference in pressure between the barn pressure port and each sidewall is measured. Thus, one static pressure sensor is required for each sidewall.

The pressure sensor will be shunted to calibrate zero and compared with an inclined manometer at various span pressures. Static pressure taps will be constructed to minimize effects of air movement from wind on the measurement.

The differential pressure transmitters are located inside the IS and polyethylene (LDPE) tubing (0.25 inches ID) will be used to connect the static pressure port in the barn or other locations to the transmitters.

SOP 11. Ventilation Fan Monitoring

May 2004

Introduction

This SOP describes the procedures to follow for the continuous determination of ventilation rate in mechanically ventilated poultry housing units. The method used for evaluating housing ventilation rate will be the Fan Curve Method (FCM). In this method, the status of fans is monitored (on/off), the static pressure is monitored across a fan or fan bank, and the appropriate fan calibration data is used to determine airflow rate delivery.

Equipment Needed

FANS monitoring system (see SOP on FANS)
SETRA Model 267 static pressure sensor or equivalent (see SOP on static pressure)
Miscellaneous wiring circuitry

Procedures

The FANS unit is to be calibrated as per BESS Laboratories (University of Illinois-Urbana Champaign). Once calibrated, the FANS unit becomes the calibrated sensor from which to calibrate all operating fans under test.

All fans in a barn will be calibrated. Each fan will be tested three times with simultaneous measurements of static pressure. The average airflow delivery rate for each fan will be recorded, along with the average static pressure measurement. This airflow versus static pressure will be used in future calculations to determine airflow delivery rate. Three static pressure levels will be tested by artificially adjusting the fresh-air intake system. Static pressures near 5, 25, and 45 Pa (0.02, 0.10, and 0.18 in wg) will be tested. A linear regression equation will be developed to determine the fan curves for each fan.

Fan Status Monitoring

The operation status for all fans in a housing unit will need to be known. It is recommended that changes or interception of signals from the existing fan control system not be used. Rather, a vibration sensor will be mounted on the fan housing itself to sense the operation of the fan. This is a new concept that has been pilot tested for three months at a laying barn in Spring 2004.

Ventilation Rate Calculations

Airflow delivery rate for a housing unit will be determined by:

1. Measuring static pressure
2. Recording fan status
3. Apply FANS calibration data to operating fans.

4. Determine housing unit airflow delivery rate for n Fans using:

where

Q	= airflow delivery rate, m^3/s (ft^3/min)
Fan_i	= individual fan status (0 = off, 1 = on)
ΔP	= static pressure difference between room and outside, Pa (in wg)
m_i	= slope for regression equation developed using FANS, m^3/s-Pa (ft^3/min-in wg)
b_i	= intercept for regression equation developed using FANS, m^3/s (ft^3/min)

SOP 13 Data Acquisition and Control

PAAQL, Purdue University (5-9-04)

Introduction

This SOP covers the data acquisition and control for three projects: 1. Laboratory test of Eco-Cure manure additive; 2. Field measurement at Mt. Victory, OH, and 3. Field measurement at Croton, OH.

Data Acquisition and Control Hardware

The hardware used in the data acquisition and control (DAC) for each project consists of one or several groups.

Laboratory test of Eco-Cure manure additive

1. FieldPoint modules (National Instruments Corporation) that include:

   One FP-2000 (control module)
   Two FP-AI-110 modules (16-bit analog inputs)
   One FP-TC-120 modules (thermocouple temperature measurement)
   Two FP-DO-401 module (digital output)

   The FieldPoint modules will be connected in the following sequence as it is configured in the file OHSITE.iak:

   FP-2000; FP-AI-110-1; FP-AI-110-2; FP-TC-120-1; FP-DO-401-1; FP-DO-401-2.

Field measurement at Mt. Victory, OH

1. FieldPoint modules (National Instruments Corporation) that include:

   One FP-1600 (control module)
   Five FP-AI-110 modules (16-bit analog inputs)
   Two FP-TC-120 modules (thermocouple temperature measurement)
   Two FP-DO-401 module (digital output)

   The FieldPoint modules will be connected in the following sequence as it is configured in the file OHSITE.iak:

   FP-1600; FP-AI-110-1; FP-AI-110-2; FP-AI-110-3; FP-AI-110-4; FP-AI-110-5; FP-TC-120-1; FP-TC-120-2; FP-DO-401-1; FP-DO-401-2.

2. One PCI-6601counter/DIO data acquisition card (National Instruments Corporation, Austin, TX) for digital input and counter.

3. One DAS-1602 DAQ card and one EXP 32 board (Measurement Computing Corporation, Middleboro, MA) for 16-bit analog input.

4. Four miniLAB™ 1008 Rugged USB-based DAQ devices (Measurement Computing Corporation, Middleboro, MA) for digital input.

Field measurement at Croton, OH

1. FieldPoint modules (National Instruments Corporation) that include:

   One FP-1600 (control module)
   Five FP-AI-110 modules (16-bit analog inputs)
   Two FP-TC-120 modules (thermocouple temperature measurement)
   Two FP-DO-401 module (digital output)

   The FieldPoint modules will be connected in the following sequence as it is configured in the file OHSITE.iak:

   FP-1600; FP-AI-110-1; FP-AI-110-2; FP-AI-110-3; FP-AI-110-4; FP-AI-110-5; FP-TC-120-1; FP-TC-120-2; FP-DO-401-1; FP-DO-401-2.

2. Three miniLAB™ 1008 Rugged USB-based DAQ devices (Measurement Computing Corporation, Middleboro, MA) for digital input and counter.

All the above hardware will be connected or controlled by a single DAC program.

Data Acquisition and Control Program

A DAC program developed by PAAQL, Purdue University using LabVIEW software (National Instruments, Co.) will be used to acquire data, automate sampling location control, display real time data, and deliver data and system operation status. Although the three DAC programs for the three different projects do not contain the same codes, the operation of the programs is similar.

The structure of the programs is schematically illustrated in Figure 5.

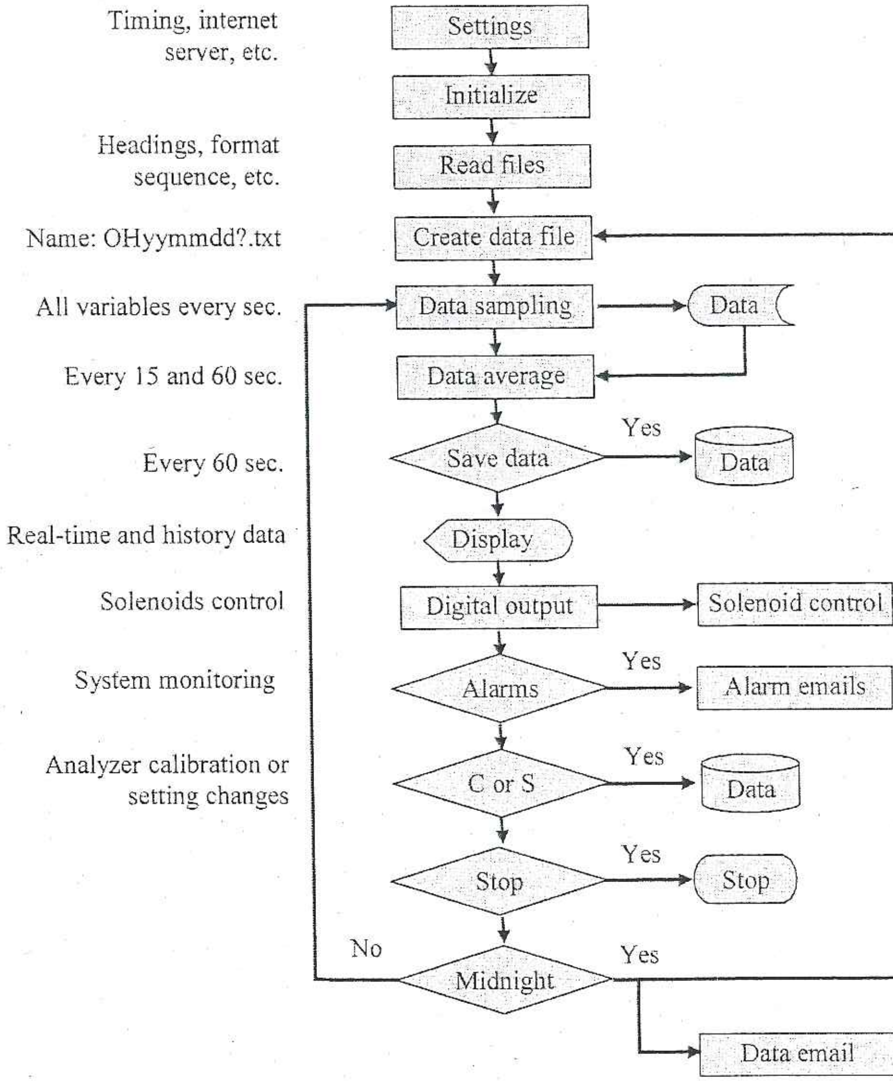


Figure 5. Flow chart of the DAC program.

Folders and Files

All the project specific program and files will be saved in a single folder in the field computer:

C:\AQOHSITE\

Three subfolders will be under C:\AQOHSITE\:

1. C:\AQOHSITE\Program\

This folder stores DAC program and hardware configuration files:
- OHSITE mmddyy.llb (DAC program, of which part of the file name "mmddyy" records the month/date/year related version information)
- OHSITE.iak (configuration file of FieldPoint data acquisition hardware)

2. C:\AQOHSITE\DACfiles\

This folder stores program setting and calibration files that are all tab delimited:

- Heading&format.txt (defines the headings and format of the data in the recorded data files)
- Sampling sequence.txt (defines automatic air sampling locations and sequence)
- Analyzers.txt (stores gas analyzer ranges, correction coefficients, calibration gas concentrations, and calibration data)
- Settings.txt (stores configuration and settings of the TEOM, temperature controller, etc.)

3. C:\AQOHSITE\Data\

This folder stores acquired measurement data files created by the LabVIEW program. To facilitate the identification of data files from different projects, a project ID (two letters, "AD" for the laboratory additive test, "OM" for the Mt. Victory site, "OC" for the Croton site) is placed at the beginning of data file names.

Measurement signals from the sensors/analyzers and control signals will be sampled every second. Sampled signals will be averaged every 15 and 60 sec and be saved in data file 1 (IDsyyyymmdd?.txt) and data file 2 (IDyyyymmdd?.txt, where "?" is a letter from "a" to "z"), respectively. Each time when the program is started or when a new day begins at midnight, the two data files will be created and saved in the "Data" folder. During DAC program testing, if the program is started for 26 times during the same day, the "?" will be "z" and cannot go up further. If this happens, the "*z.txt" file in the "Data" folder will need to be cleaned in order to re-run the program.

When more and more data files are generated in the C:\AQOHSITE\Data\ folder, and the folder becomes too big for backing up in a single CD, it is recommended that old data files be moved to a new folder C:\AQOHSITE Data (Refer to SOP 20. Data Management at IS).

The data files will have Tab-Delimited text format. The first row will contain day and date and a brief note. The second row will be data headings. Measurement data will start from the third row (Table 1).

Table 1. First rows of data files.

Wednesday, May 05, 2004		Data from Croton. Sampling Location#: 1=Ambient air, 2=Exhaust 1, ...					
Date & Time	Loc#	NH3, ppm	NO, ppm	...	...	CO2, ppm	...
05/04/2004 17:32:02	1	23	0.1	...	...	1250	...
...	...	...	...	...	...	...	...

Data columns and their corresponding sensor connections will be arranged as shown in Table 2 to 4.

Testing and Running the DAC Program

At Initial Operation

1. Run the OHSITE.iak file from FieldPoint Explorer;
2. Check each FieldPoint module to ensure that they are correctly configured and are ready to acquire data;
3. If modifications are made and need to be kept, save the OHSITE.iak file;
4. Run Measurement and Instruments to test the status of the PCI-6601 card if it is installed;
5. Open the OHSITE yymmdd.llb from LabView 6.1 or from C:\AQOHSITE\Program\ by double clicking it. In the File Dialog window that appears, select AQOHSITE.vi and click OK. The panel of AQOHSITE.vi appears;
6. Select menu "Windows"- "Show Diagram." In the Diagram window, select frame 0 in the left sequence block. Check settings and make necessary changes. If the changes should be permanent, go to File and Save to save the changes.
7. To run the program, click the run button (a white arrow) in the upper-left corner of the Panel or Diagram window;
8. To stop the program, hold and release the button "Stop" at the upper-right corner of the Panel window. In the dialog window that appears, select OK.

Subsequent Operations

1. Open OHSITE yymmdd.llb from LabView 6.1 or from C:\AQOHSITE\Program\ by double clicking it.. In the File Dialog window that appears, select AQOHSITE.vi and click OK. The panel of AQOHSITE.vi appears;
2. To run the program, click the run button (a white arrow) in the upper-left corner of the Panel window;
3. To stop the program, hold and release the "Stop" button of the Panel window. At the dialog window that appears, select OK.

Bugs and Suggestions

Bugs found in the DAC program and suggestions of improvement can be directed by email (jiqin@ecn.purdue.edu) or phone call (765-494-1195) to Ji-Qin Ni, Purdue University. Upgraded DAC program files will be sent from Purdue University to the test computer via internet connection.

Table 2. Data file and sensor arrangement (For Laboratory measurement).

Data Col	File heading	Sensor/solenoid	Range	DAQ hardware	Ch#	Signal or power
1	Date & Time	---		---	---	PC clock
2	Smpl loc#	---		---	---	Waveform
3	NH3, ppm	NH3 analyzer	0-200 ppm	FP-AI-110-1	0	0-10 VDC
4	NO, ppm	NH3 analyzer	0-50 ppm	FP-AI-110-1	1	0-10 VDC
5	H2S, ppb	H2S analyzer	0-5000 ppb	FP-AI-110-1	2	0-10 VDC
10	SO2, ppb	H2S analyzer	0-5000 ppb	FP-AI-110-1	3	0-10 VDC
11	CO2, ppm	CO2 monitor	0-5000 ppm	FP-AI-110-1	4	0.004-0.02 A
12	Sample flow, Lpm	Mass flow meter	0-10 Lpm	FP-AI-110-1	5	0-10 VDC
13	P in M-s, Pa	Setra Model 230	0-1 psi	FP-AI-110-1	6	0.004-0.02 A
14	dP1 Exhaust air, Pa	Ashcroft, C1	+/-0.1 WC(+/-24.9Pa)	FP-AI-110-1	7	0.004-0.02 A
15	P in M-a, psi	WIKA Tronic Line	0-10 psi	FP-AI-110-1	0	0.004-0.02 A
16	T in M-a, C	Humitter/50Y/YX	-40 - 60 °C	FP-AI-110-1	1	0-1 VDC
17	RH in M-a, %	Humitter/50Y/YX	0-100 %	FP-AI-110-1	2	0-1 VDC
18	Reserved			FP-AI-110-2	3	
19	dP2 Cooler-lab, Pa	Ashcroft, C1	+/-0.1 WC(+/-24.9Pa)	FP-AI-110-2	4	0.004-0.02 A
20	dP3 Outdoor-lab, Pa	Ashcroft, C1	+/-0.1 WC(+/-24.9Pa)	FP-AI-110-2	5	0.004-0.02 A
21	dP4 AQlab-Hood, Pa	Ashcroft, C1	+/-0.1 WC(+/-24.9Pa)	FP-AI-110-2	6	0.004-0.02 A
22	Reserved			FP-AI-110-2	7	
23	T 1, C	Thermocouple		FP-TC-120-1	0	
24	T2, C	Thermocouple		FP-TC-120-1	1	
25	T3, C	Thermocouple		FP-TC-120-1	2	
26	T4, C	Thermocouple		FP-TC-120-1	3	
27	AQ Lab, C	Thermocouple		FP-TC-120-1	4	
28	Reserved	Thermocouple		FP-TC-120-1	5	
29	Reserved	Thermocouple		FP-TC-120-1	6	
30	Reserved	Thermocouple		FP-TC-120-1	7	
	---	Solenoid 1		FP-DO-401	1	24 VDC
	---	Solenoid 2		FP-DO-401	2	24 VDC
	---	Solenoid 3		FP-DO-401	3	24 VDC
	---	Solenoid 4		FP-DO-401	4	24 VDC
	---	Solenoid 5		FP-DO-401	5	24 VDC
	---	Solenoid 6		FP-DO-401	6	24 VDC
	---	Solenoid 7		FP-DO-401	7	24 VDC
	---	Solenoid 8		FP-DO-401	8	24 VDC
	---	Solenoid 9		FP-DO-401	9	24 VDC
	---	Solenoid 10		FP-DO-401	10	24 VDC
	---	Solenoid 11		FP-DO-401	11	24 VDC
	---	Solenoid 12		FP-DO-401	12	24 VDC
	---	Solenoid 13		FP-DO-401	13	24 VDC
	---	Solenoid 14		FP-DO-401	14	24 VDC
	---	Solenoid 15		FP-DO-401	15	24 VDC
	---	Solenoid 16		FP-DO-401	16	24 VDC
	---	Solenoid 17		FP-DO-401-2	1	24 VDC
	---	Solenoid 18		FP-DO-401-2	2	24 VDC
	---	Solenoid 19		FP-DO-401-2	3	24 VDC
	---	Solenoid 20		FP-DO-401-2	4	24 VDC
	---	Solenoid 21		FP-DO-401-2	5	24 VDC
	Reserved			FP-DO-401-2	6	
	Reserved			FP-DO-401-2	7	
	Reserved			FP-DO-401-2	8	
	Reserved			FP-DO-401-2	9	
	Reserved			FP-DO-401-2	10	
	Reserved			FP-DO-401-2	11	
	Reserved			FP-DO-401-2	12	
	Reserved			FP-DO-401-2	13	
	Reserved			FP-DO-401-2	14	
	Reserved			FP-DO-401-2	15	
	Reserved			FP-DO-401-2	16	

Table 3. Data file and sensor arrangement (For Mt. Victory, Ohio measurement).

Data Col	File heading	Sensor/controller	Range	DAC hardware	Ch#	Signal or EV
1	Date & Time	---		---	---	PC clock
2	Smpl loc#	---		---	---	LabVIEW
3	NH_3, ppm	NH_3 analyzer	0-200 ppm	FP-AI-110-1	0	0-10 VDC
4	NO, ppm	NH_3 analyzer	0-50 ppm	FP-AI-110-1	1	0-10 VDC
5	NH3b, ppm	MSA analyzer	0-1000 ppm	FP-AI-110-1	2	4-20 mA
6	CO2a, ppm	CO_2 2K	0-2000 ppm	FP-AI-110-1	3	4-20 mA
7	CO2b, ppm	CO_2 10K	0-10000 ppm	FP-AI-110-1	4	4-20 mA
8	Smpl P, Pa	Setra P sensor	0-5 psi	FP-AI-110-1	5	4-20 mA
9	Smpl Q, L/m	Mass flow	0-10 Lpm	FP-AI-110-1	6	0-10 VDC
10	RH1, %	HMW61Y #1	0-100 %	FP-AI-110-1	7	4-20 mA
11	T(RH)1, °C	HMW61Y #1	-40 - 60 °C	FP-AI-110-2	0	4-20 mA
12	RH2, %	HMW61Y #2	0-100 %	FP-AI-110-2	1	4-20 mA
13	T(RH)2, °C	HMW61Y #2	-40 - 60 °C	FP-AI-110-2	2	4-20 mA
14	RH3, %	HMW61Y #3	0-100 %	FP-AI-110-2	3	4-20 mA
15	T(RH)3, °C	HMW61Y #3	-40 - 60 °C	FP-AI-110-2	4	4-20 mA
16	Mass, μg/m³	TEOM #1	Adjustable	FP-AI-110-2	5	0-10 VDC
17	Filter, %	TEOM #1	0-100%	FP-AI-110-2	6	0-10 VDC
18	Atm P, Pa	TEOM #1		FP-AI-110-2	7	0-10 VDC
19	Mass2, μg/m³	TEOM #2	Adjustable	FP-AI-110-3	0	0-10 VDC
20	Filter2, %	TEOM #2	0-100%	FP-AI-110-3	1	0-10 VDC
21	Mass3, μg/m³	TEOM #3	Adjustable	FP-AI-110-3	2	0-10 VDC
22	Filter3, %	TEOM #3	0-100%	FP-AI-110-3	3	0-10 VDC
23	Radiation, W/m²	Solar sensor		FP-AI-110-3	4	0-10 VDC
24	Wind D, °	Wind sensor	0-360 degree	FP-AI-110-3	5	0-10 VDC
25	Wind V, m/s	Wind sensor	0-30 m/s	NI-6601	Ctr 0	Pulse
26	dP1, Pa	Setra P sensor #1	-100 to +100 Pa	FP-AI-110-3	6	0-10 VDC
27	dP2, Pa	Setra P sensor #2	-100 to +100 Pa	FP-AI-110-3	7	0-10 VDC
28	dP3, Pa	Setra P sensor #3	-100 to +100 Pa	FP-AI-110-4	0	0-10 VDC
29	dP4, Pa	Setra P sensor #4	-100 to +100 Pa	FP-AI-110-4	1	0-10 VDC
30	dP5, Pa	Setra P sensor #5	-100 to +100 Pa	FP-AI-110-4	2	0-10 VDC
31	dP smpl exhaust, Pa	Ashcroft, C1	+/-0.1 WC(+/-24.9Pa)	FP-AI-110-4	3	0-10 VDC
32	SVA1, VDC	Anemometer #1		FP-AI-110-4	4	0-1 VDC
33	SVA2, VDC	Anemometer #2		FP-AI-110-4	5	0-1 VDC
34	SVA3, VDC	Anemometer #3		FP-AI-110-4	6	0-1 VDC
35	SVA4, VDC	Anemometer #4		FP-AI-110-4	7	0-1 VDC
36	SVA5, VDC	Anemometer #5		FP-AI-110-5	0	0-1 VDC
37	SVA6, VDC	Anemometer #6		FP-AI-110-5	1	0-1 VDC
38	SVA7, VDC	Anemometer #7		FP-AI-110-5	2	0-1 VDC
39	SVA8, VDC	Anemometer #8		FP-AI-110-5	3	0-1 VDC
40	SVA9, VDC	Anemometer #9		FP-AI-110-5	4	0-1 VDC
41	SVA10, VDC	Anemometer #10		FP-AI-110-5	5	0-1 VDC
42	SVA11, VDC	Anemometer #11		FP-AI-110-5	6	0-1 VDC
43	SVA12, VDC	Anemometer #12		FP-AI-110-5	7	0-1 VDC
44	Act1, VDC	Activity sensor #1		DAS 1602	0	0-2 VDC
45	Act2, VDC	Activity sensor #2		DAS 1602	1	0-2 VDC
46	Act3, VDC	Activity sensor #3		DAS 1602	2	0-2 VDC
47	Act4, VDC	Activity sensor #4		DAS 1602	3	0-2 VDC
48	Act5, VDC	Activity sensor #5		DAS 1602	4	0-2 VDC
49	Act6, VDC	Activity sensor #6		DAS 1602	5	0-2 VDC
50	Act7, VDC	Activity sensor #7		DAS 1602	6	0-2 VDC
51	Act8, VDC	Activity sensor #8		DAS 1602	7	0-2 VDC
52	Act9, VDC	Activity sensor #9		DAS 1602	8	0-2 VDC
53	Act10, VDC	Activity sensor #10		DAS 1602	9	0-2 VDC
54	Act11, VDC	Activity sensor #11		DAS 1602	10	0-2 VDC
55	Act12, VDC	Activity sensor #12		DAS 1602	11	0-2 VDC
56	Act13, VDC	Activity sensor #13		DAS 1602	12	0-2 VDC
57	Act14, VDC	Activity sensor #14		DAS 1602	13	0-2 VDC
58	Act15, VDC	Activity sensor #15		DAS 1602	14	0-2 VDC
59	Act16, VDC	Activity sensor #16		DAS 1602	15	0-2 VDC

Table 3. (continued)

Data Col	File heading	Sensor/controller	Range	DAC hardware	Ch#	Signal or EV
60	Act17, VDC	Activity sensor #17		DAS 1602	16	0-2 VDC
61	Act18, VDC	Activity sensor #18		DAS 1602	17	0-2 VDC
62	Act19, VDC	Activity sensor #19		DAS 1602	18	0-2 VDC
63	Act20, VDC	Activity sensor #20		DAS 1602	19	0-2 VDC
64	Reserved			DAS 1602	20	0-2 VDC
65	Reserved			DAS 1602	21	0-2 VDC
66	Reserved			DAS 1602	22	0-2 VDC
67	Reserved			DAS 1602	23	0-2 VDC
68	Reserved			DAS 1602	24	0-2 VDC
69	Reserved			DAS 1602	25	0-2 VDC
70	Reserved			DAS 1602	26	0-2 VDC
71	Reserved			DAS 1602	27	0-2 VDC
72	Reserved			DAS 1602	28	0-2 VDC
73	Reserved			DAS 1602	29	0-2 VDC
74	Reserved			DAS 1602	30	0-2 VDC
75	Reserved			DAS 1602	31	0-2 VDC
76	T1, °C	Thermocouple #1		FP-TC-120-1	0	
77	T2, °C	Thermocouple #2		FP-TC-120-1	1	
78	T3, °C	Thermocouple #3		FP-TC-120-1	2	
79	T4, °C	Thermocouple #4		FP-TC-120-1	3	
80	T5, °C	Thermocouple #5		FP-TC-120-1	4	
81	T6, °C	Thermocouple #6		FP-TC-120-1	5	
82	T7, °C	Thermocouple #7		FP-TC-120-1	6	
83	T8, °C	Thermocouple #8		FP-TC-120-1	7	
84	T9, °C	Thermocouple #9		FP-TC-120-2	0	
85	T10, °C	Thermocouple #10		FP-TC-120-2	1	
86	T11, °C	Thermocouple #11		FP-TC-120-2	2	
87	T12, °C	Thermocouple #12		FP-TC-120-2	3	
88	T13, °C	Thermocouple #13		FP-TC-120-2	4	
89	T14, °C	Thermocouple #14		FP-TC-120-2	5	
90	T15, °C	Thermocouple #15		FP-TC-120-2	6	
91	T16, °C	Thermocouple #16		FP-TC-120-2	7	
92	Fan stg 1, % time	Relay #1		NI-PCI-6601	0	0/5 VDC
93	Fan stg 2, % time	Relay #2		NI-PCI-6601	1	0/5 VDC
94	Fan stg 3, % time	Relay #3		NI-PCI-6601	2	0/5 VDC
95	Fan stg 4, % time	Relay #4		NI-PCI-6601	3	0/5 VDC
96	Fan stg 5, % time	Relay #5		NI-PCI-6601	4	0/5 VDC
97	Fan stg 6, % time	Relay #6		NI-PCI-6601	5	0/5 VDC
98	Fan stg 7, % time	Relay #7		NI-PCI-6601	6	0/5 VDC
99	Fan stg 8, % time	Relay #8		NI-PCI-6601	7	0/5 VDC
100	Fan stg 9, % time	Relay #9		NI-PCI-6601	8	0/5 VDC
101	Fan stg 10, % time	Relay #10		NI-PCI-6601	9	0/5 VDC
102	Fan stg 11, % time	Relay #11		NI-PCI-6601	10	0/5 VDC
103	Fan stg 12, % time	Relay #12		NI-PCI-6601	11	0/5 VDC
104	Fan stg 13, % time	Relay #13		NI-PCI-6601	12	0/5 VDC
105	2-Fan stg 1, % time	Relay #14		NI-PCI-6601	13	0/5 VDC
106	2-Fan stg 2, % time	Relay #15		NI-PCI-6601	14	0/5 VDC
107	2-Fan stg 3, % time	Relay #16		NI-PCI-6601	15	0/5 VDC
108	2-Fan stg 4, % time	Relay #17		NI-PCI-6601	16	0/5 VDC
109	2-Fan stg 5, % time	Relay #18		NI-PCI-6601	17	0/5 VDC
110	2-Fan stg 6, % time	Relay #19		NI-PCI-6601	18	0/5 VDC
111	2-Fan stg 7, % time	Relay #20		NI-PCI-6601	19	0/5 VDC
112	2-Fan stg 8, % time	Relay #21		NI-PCI-6601	20	0/5 VDC
113	2-Fan stg 9, % time	Relay #22		NI-PCI-6601	21	0/5 VDC
114	2-Fan stg 10, % time	Relay #23		NI-PCI-6601	22	0/5 VDC
115	2-Fan stg 11, % time	Relay #24		NI-PCI-6601	23	0/5 VDC
116	2-Fan stg 12, % time	Relay #25		NI-PCI-6601	24	0/5 VDC
117	2-Fan stg 13, % time	Relay #26		NI-PCI-6601	25	0/5 VDC
118	Reserved			NI-PCI-6601	26	0/5 VDC
119	Reserved			NI-PCI-6601	27	0/5 VDC
120	Reserved			NI-PCI-6601	28	0/5 VDC

Table 3. (continued)

Data Col	File heading	Sensor/controller	Range	DAC hardware	Ch#	Signal or EV
121	Reserved			NI-PCI-6601	29	0/5 VDC
122	Reserved			NI-PCI-6601	30	0/5 VDC
123	Reserved			NI-PCI-6601	31	0/5 VDC
124	Fan #1, % time	V-sensor #1		miniLAB1008-1	0	0/5 VDC
125	Fan #2, % time	V-sensor #2		miniLAB1008-1	1	0/5 VDC
126	Fan #3, % time	V-sensor #3		miniLAB1008-1	2	0/5 VDC
127	Fan #4, % time	V-sensor #4		miniLAB1008-1	3	0/5 VDC
128	Fan #5, % time	V-sensor #5		miniLAB1008-1	4	0/5 VDC
129	Fan #6, % time	V-sensor #6		miniLAB1008-1	5	0/5 VDC
130	Fan #7, % time	V-sensor #7		miniLAB1008-1	6	0/5 VDC
131	Fan #8, % time	V-sensor #8		miniLAB1008-1	7	0/5 VDC
132	Fan #9, % time	V-sensor #9		miniLAB1008-1	8	0/5 VDC
133	Fan #10, % time	V-sensor #10		miniLAB1008-1	9	0/5 VDC
134	Fan #11, % time	V-sensor #11		miniLAB1008-1	10	0/5 VDC
135	Fan #12, % time	V-sensor #12		miniLAB1008-1	11	0/5 VDC
136	Fan #13, % time	V-sensor #13		miniLAB1008-1	12	0/5 VDC
137	Fan #14, % time	V-sensor #14		miniLAB1008-1	13	0/5 VDC
138	Fan #15, % time	V-sensor #15		miniLAB1008-1	14	0/5 VDC
139	Fan #16, % time	V-sensor #16		miniLAB1008-1	15	0/5 VDC
140	Fan #17, % time	V-sensor #17		miniLAB1008-1	16	0/5 VDC
141	Fan #18, % time	V-sensor #18		miniLAB1008-1	17	0/5 VDC
142	Fan #19, % time	V-sensor #19		miniLAB1008-1	18	0/5 VDC
143	Fan #20, % time	V-sensor #20		miniLAB1008-1	19	0/5 VDC
144	Fan #21, % time	V-sensor #21		miniLAB1008-1	20	0/5 VDC
145	Fan #22, % time	V-sensor #22		miniLAB1008-1	21	0/5 VDC
146	Fan #23, % time	V-sensor #23		miniLAB1008-1	22	0/5 VDC
147	Fan #24, % time	V-sensor #24		miniLAB1008-1	23	0/5 VDC
148	Fan #25, % time	V-sensor #25		miniLAB1008-1	24	0/5 VDC
149	Fan #26, % time	V-sensor #26		miniLAB1008-2	0	0/5 VDC
150	Fan #27, % time	V-sensor #27		miniLAB1008-2	1	0/5 VDC
151	Fan #28, % time	V-sensor #28		miniLAB1008-2	2	0/5 VDC
152	Fan #29, % time	V-sensor #29		miniLAB1008-2	3	0/5 VDC
153	Fan #30, % time	V-sensor #30		miniLAB1008-2	4	0/5 VDC
154	Fan #31, % time	V-sensor #31		miniLAB1008-2	5	0/5 VDC
155	Fan #32, % time	V-sensor #32		miniLAB1008-2	6	0/5 VDC
156	Fan #33, % time	V-sensor #33		miniLAB1008-2	7	0/5 VDC
157	Fan #34, % time	V-sensor #34		miniLAB1008-2	8	0/5 VDC
158	Fan #35, % time	V-sensor #35		miniLAB1008-2	9	0/5 VDC
159	Fan #36, % time	V-sensor #36		miniLAB1008-2	10	0/5 VDC
160	Fan #37, % time	V-sensor #37		miniLAB1008-2	11	0/5 VDC
161	Fan #38, % time	V-sensor #38		miniLAB1008-2	12	0/5 VDC
162	Fan #39, % time	V-sensor #39		miniLAB1008-2	13	0/5 VDC
163	Fan #40, % time	V-sensor #40		miniLAB1008-2	14	0/5 VDC
164	Fan #41, % time	V-sensor #41		miniLAB1008-2	15	0/5 VDC
165	Fan #42, % time	V-sensor #42		miniLAB1008-2	16	0/5 VDC
166	Fan #43, % time	V-sensor #43		miniLAB1008-2	17	0/5 VDC
167	Fan #44, % time	V-sensor #44		miniLAB1008-2	18	0/5 VDC
168	Fan #45, % time	V-sensor #45		miniLAB1008-2	19	0/5 VDC
169	Fan #46, % time	V-sensor #46		miniLAB1008-2	20	0/5 VDC
170	Fan #47, % time	V-sensor #47		miniLAB1008-2	21	0/5 VDC
171	Fan #48, % time	V-sensor #48		miniLAB1008-2	22	0/5 VDC
172	Fan #49, % time	V-sensor #49		miniLAB1008-2	23	0/5 VDC
173	Fan #50, % time	V-sensor #50		miniLAB1008-2	24	0/5 VDC
174	2-Fan #1, % time	V-sensor #51		miniLAB1008-3	0	0/5 VDC
175	2-Fan #2, % time	V-sensor #52		miniLAB1008-3	1	0/5 VDC
176	2-Fan #3, % time	V-sensor #53		miniLAB1008-3	2	0/5 VDC
177	2-Fan #4, % time	V-sensor #54		miniLAB1008-3	3	0/5 VDC
178	2-Fan #5, % time	V-sensor #55		miniLAB1008-3	4	0/5 VDC
179	2-Fan #6, % time	V-sensor #56		miniLAB1008-3	5	0/5 VDC
180	2-Fan #7, % time	V-sensor #57		miniLAB1008-3	6	0/5 VDC
181	2-Fan #8, % time	V-sensor #58		miniLAB1008-3	7	0/5 VDC

Table 3. (continued)

Data Col	File heading	Sensor/controller	Range	DAC hardware	Ch#	Signal or EV
182	2-Fan #9, % time	V-sensor #59		miniLAB1008-3	8	0/5 VDC
183	2-Fan #10, % time	V-sensor #60		miniLAB1008-3	9	0/5 VDC
184	2-Fan #11, % time	V-sensor #61		miniLAB1008-3	10	0/5 VDC
185	2-Fan #12, % time	V-sensor #62		miniLAB1008-3	11	0/5 VDC
186	2-Fan #13, % time	V-sensor #63		miniLAB1008-3	12	0/5 VDC
187	2-Fan #14, % time	V-sensor #64		miniLAB1008-3	13	0/5 VDC
188	2-Fan #15, % time	V-sensor #65		miniLAB1008-3	14	0/5 VDC
189	2-Fan #16, % time	V-sensor #66		miniLAB1008-3	15	0/5 VDC
190	2-Fan #17, % time	V-sensor #67		miniLAB1008-3	16	0/5 VDC
191	2-Fan #18, % time	V-sensor #68		miniLAB1008-3	17	0/5 VDC
192	2-Fan #19, % time	V-sensor #69		miniLAB1008-3	18	0/5 VDC
193	2-Fan #20, % time	V-sensor #70		miniLAB1008-3	19	0/5 VDC
194	2-Fan #21, % time	V-sensor #71		miniLAB1008-3	20	0/5 VDC
195	2-Fan #22, % time	V-sensor #72		miniLAB1008-3	21	0/5 VDC
196	2-Fan #23, % time	V-sensor #73		miniLAB1008-3	22	0/5 VDC
197	2-Fan #24, % time	V-sensor #74		miniLAB1008-3	23	0/5 VDC
198	2-Fan #25, % time	V-sensor #75		miniLAB1008-3	24	0/5 VDC
199	2-Fan #26, % time	V-sensor #76		miniLAB1008-4	0	0/5 VDC
200	2-Fan #27, % time	V-sensor #77		miniLAB1008-4	1	0/5 VDC
201	2-Fan #28, % time	V-sensor #78		miniLAB1008-4	2	0/5 VDC
202	2-Fan #29, % time	V-sensor #79		miniLAB1008-4	3	0/5 VDC
203	2-Fan #30, % time	V-sensor #80		miniLAB1008-4	4	0/5 VDC
204	2-Fan #31, % time	V-sensor #81		miniLAB1008-4	5	0/5 VDC
205	2-Fan #32, % time	V-sensor #82		miniLAB1008-4	6	0/5 VDC
206	2-Fan #33, % time	V-sensor #83		miniLAB1008-4	7	0/5 VDC
207	2-Fan #34, % time	V-sensor #84		miniLAB1008-4	8	0/5 VDC
208	2-Fan #35, % time	V-sensor #85		miniLAB1008-4	9	0/5 VDC
209	2-Fan #36, % time	V-sensor #86		miniLAB1008-4	10	0/5 VDC
210	2-Fan #37, % time	V-sensor #87		miniLAB1008-4	11	0/5 VDC
211	2-Fan #38, % time	V-sensor #88		miniLAB1008-4	12	0/5 VDC
212	2-Fan #39, % time	V-sensor #89		miniLAB1008-4	13	0/5 VDC
213	2-Fan #40, % time	V-sensor #90		miniLAB1008-4	14	0/5 VDC
214	2-Fan #41, % time	V-sensor #91		miniLAB1008-4	15	0/5 VDC
215	2-Fan #42, % time	V-sensor #92		miniLAB1008-4	16	0/5 VDC
216	2-Fan #43, % time	V-sensor #93		miniLAB1008-4	17	0/5 VDC
217	2-Fan #44, % time	V-sensor #94		miniLAB1008-4	18	0/5 VDC
218	2-Fan #45, % time	V-sensor #95		miniLAB1008-4	19	0/5 VDC
219	2-Fan #46, % time	V-sensor #96		miniLAB1008-4	20	0/5 VDC
220	2-Fan #47, % time	V-sensor #97		miniLAB1008-4	21	0/5 VDC
221	2-Fan #48, % time	V-sensor #98		miniLAB1008-4	22	0/5 VDC
222	2-Fan #49, % time	V-sensor #99		miniLAB1008-4	23	0/5 VDC
223	2-Fan #50, % time	V-sensor #100		miniLAB1008-4	24	0/5 VDC
	---	Solenoid 1		FP-DO-401-1	0	24 VDC
	---	Solenoid 2		FP-DO-401-1	1	24 VDC
	---	Solenoid 3		FP-DO-401-1	2	24 VDC
	---	Solenoid 4		FP-DO-401-1	3	24 VDC
	---	Solenoid 5		FP-DO-401-1	4	24 VDC
	---	Solenoid 6		FP-DO-401-1	5	24 VDC
	---	Solenoid 7		FP-DO-401-1	6	24 VDC
	---	Solenoid 8		FP-DO-401-1	7	24 VDC
	---	Solenoid 9		FP-DO-401-1	8	24 VDC
	---	Solenoid 10		FP-DO-401-1	9	24 VDC
	---	Solenoid 11		FP-DO-401-1	10	24 VDC
	---	Solenoid 12		FP-DO-401-1	11	24 VDC
	---	Solenoid 13		FP-DO-401-1	12	24 VDC
	---	Reserved		FP-DO-401-1	13	
	---	Reserved		FP-DO-401-1	14	
	---	Reserved		FP-DO-401-1	15	
	---	Calibration gas-1		FP-DO-401-2	0	24 VDC
	---	Calibration gas-2		FP-DO-401-2	1	24 VDC
	---	Calibration gas-3		FP-DO-401-2	2	24 VDC
	---	Calibration gas-4		FP-DO-401-2	3	24 VDC

Table 3. (continued)

Data Col	File heading	Sensor/controller	Range	DAC hardware	Ch#	Signal or EV
	---	Calibration gas-5		FP-DO-401-2	4	24 VDC
	---	Reserved		FP-DO-401-2	5	
	---	Reserved		FP-DO-401-2	6	
	---	Reserved		FP-DO-401-2	7	
	---	Reserved		FP-DO-401-2	8	
	---	Reserved		FP-DO-401-2	9	
	---	Reserved		FP-DO-401-2	10	
	---	Reserved		FP-DO-401-2	11	
	---	Reserved		FP-DO-401-2	12	
	---	Reserved		FP-DO-401-2	13	
	---	Reserved		FP-DO-401-2	14	
	---	Reserved		FP-DO-401-2	15	

Table 4. Data file and sensor arrangement (For Croton, Ohio measurement).

Data Col	File heading	Sensor/controller	Range	DAC hardware	Ch#	Signal or EV
1	Date & Time	---		---	---	PC clock
2	Smpl loc#	---		---	---	LabVIEW
3	NH3, ppm	NH3 analyzer	0-200 ppm	FP-AI-110-1	0	0-10 VDC
4	NO, ppm	NH3 analyzer	0-50 ppm	FP-AI-110-1	1	0-10 VDC
5	NH3b, ppm	MSA analyzer	0-1000 ppm	FP-AI-110-1	2	4-20 mA
6	CO2a, ppm	CO2 2K	0-2000 ppm	FP-AI-110-1	3	4-20 mA
7	CO2b, ppm	CO2 10K	0-10000 ppm	FP-AI-110-1	4	4-20 mA
8	Smpl P, Pa	Setra P sensor	0-5 psi	FP-AI-110-1	5	4-20 mA
9	Smpl Q, L/m	Mass flow	0-10 Lpm	FP-AI-110-1	6	0-10 VDC
10	RH1, %	HMW61Y #1	0-100 %	FP-AI-110-1	7	4-20 mA
11	T(RH)1, °C	HMW61Y #1	-40 - 60 °C	FP-AI-110-2	0	4-20 mA
12	RH2, %	HMW61Y #2	0-100 %	FP-AI-110-2	1	4-20 mA
13	T(RH)2, °C	HMW61Y #2	-40 - 60 °C	FP-AI-110-2	2	4-20 mA
14	Mass, μg/m³	TEOM #1	Adjustable	FP-AI-110-2	3	0-10 VDC
15	Filter, %	TEOM #1	0-100%	FP-AI-110-2	4	0-10 VDC
16	Atm P, Pa	TEOM #1		FP-AI-110-2	5	0-10 VDC
17	Mass2, μg/m³	TEOM #2	Adjustable	FP-AI-110-2	6	0-10 VDC
18	Filter2, %	TEOM #2	0-100%	FP-AI-110-2	7	0-10 VDC
19	Radiation, W/m²	Solar sensor		FP-AI-110-3	0	0-10 VDC
20	dP1, Pa	Setra P sensor #-3	-100 to +100 Pa	FP-AI-110-3	1	0-10 VDC
21	dP2, Pa	Setra P sensor #-2	-100 to +100 Pa	FP-AI-110-3	2	0-10 VDC
22	dP3, Pa	Setra P sensor #-1	-100 to +100 Pa	FP-AI-110-3	3	0-10 VDC
23	dP smpl exhaust, Pa	Ashcroft, C1	+/-0.1 WC(+/-24.9Pa)	FP-AI-110-3	4	0-10 VDC
24	Wind D, °	Met sensor	0-360 degree	FP-AI-110-3	5	0-10 VDC
25	Wind V, m/s	Met sensor	0-30 m/s	miniLAB1008-1	Ctr 0	Pulse
26	SVA1, VDC	Anemometer #1		FP-AI-110-3	6	0-1 VDC
27	SVA2, VDC	Anemometer #2		FP-AI-110-3	7	0-1 VDC
28	SVA3, VDC	Anemometer #3		FP-AI-110-4	0	0-1 VDC
29	SVA4, VDC	Anemometer #4		FP-AI-110-4	1	0-1 VDC
30	SVA5, VDC	Anemometer #5		FP-AI-110-4	2	0-1 VDC
31	SVA6, VDC	Anemometer #6		FP-AI-110-4	3	0-1 VDC
32	SVA7, VDC	Anemometer #7		FP-AI-110-4	4	0-1 VDC
33	Act1, VDC	Activity sensor #1		FP-AI-110-4	5	0-2 VDC
34	Act2, VDC	Activity sensor #2		FP-AI-110-4	6	0-2 VDC
35	Act3, VDC	Activity sensor #3		FP-AI-110-4	7	0-2 VDC
36	Act4, VDC	Activity sensor #4		FP-AI-110-5	0	0-2 VDC
37	Act5, VDC	Activity sensor #5		FP-AI-110-5	1	0-2 VDC
38	Act6, VDC	Activity sensor #6		FP-AI-110-5	2	0-2 VDC
39	Act7, VDC	Activity sensor #7		FP-AI-110-5	3	0-2 VDC
40	Act8, VDC	Activity sensor #8		FP-AI-110-5	4	0-2 VDC
41	Act9, VDC	Activity sensor #9		FP-AI-110-5	5	0-2 VDC
42	Reserved			FP-AI-110-5	6	
43	Reserved			FP-AI-110-5	7	
44	T1, °C	Thermocouple #1		FP-TC-120-1	0	
45	T2, °C	Thermocouple #2		FP-TC-120-1	1	
46	T3, °C	Thermocouple #3		FP-TC-120-1	2	
47	T4, °C	Thermocouple #4		FP-TC-120-1	3	
48	T5, °C	Thermocouple #5		FP-TC-120-1	4	
49	T6, °C	Thermocouple #6		FP-TC-120-1	5	
50	T7, °C	Thermocouple #7		FP-TC-120-1	6	
51	T8, °C	Thermocouple #8		FP-TC-120-1	7	
52	T9, °C	Thermocouple #9		FP-TC-120-2	0	
53	T10, °C	Thermocouple #10		FP-TC-120-2	1	
54	T11, °C	Thermocouple #11		FP-TC-120-2	2	
55	T12, °C	Thermocouple #12		FP-TC-120-2	3	
56	Reserved			FP-TC-120-2	4	
57	Reserved			FP-TC-120-2	5	
58	Reserved			FP-TC-120-2	6	
59	Reserved			FP-TC-120-2	7	

Table 4. (continued)

Data Col	File heading	Sensor/controller	Range	DAC hardware	Ch#	Signal or EV
60	Fan stg 1, % time	Relay #1		miniLAB1008-1	0	0/5 VDC
61	Fan stg 2, % time	Relay #2		miniLAB1008-1	1	0/5 VDC
62	Fan stg 3, % time	Relay #3		miniLAB1008-1	2	0/5 VDC
63	Fan stg 4, % time	Relay #4		miniLAB1008-1	3	0/5 VDC
64	Fan stg 5, % time	Relay #5		miniLAB1008-1	4	0/5 VDC
65	Fan stg 6, % time	Relay #6		miniLAB1008-1	5	0/5 VDC
66	Fan stg 7, % time	Relay #7		miniLAB1008-1	6	0/5 VDC
67	Fan stg 8, % time	Relay #8		miniLAB1008-1	7	0/5 VDC
68	Fan stg 9, % time	Relay #9		miniLAB1008-1	8	0/5 VDC
69	Fan stg 10, % time	Relay #10		miniLAB1008-1	9	0/5 VDC
70	Fan stg 11, % time	Relay #11		miniLAB1008-1	10	0/5 VDC
71	Fan stg 12, % time	Relay #12		miniLAB1008-1	11	0/5 VDC
72	Fan stg 13, % time	Relay #13		miniLAB1008-1	12	0/5 VDC
73	Fan #1, % time	V-sensor #1		miniLAB1008-1	13	0/5 VDC
74	Fan #2, % time	V-sensor #2		miniLAB1008-1	14	0/5 VDC
75	Fan #3, % time	V-sensor #3		miniLAB1008-1	15	0/5 VDC
76	Fan #4, % time	V-sensor #4		miniLAB1008-1	16	0/5 VDC
77	Fan #5, % time	V-sensor #5		miniLAB1008-1	17	0/5 VDC
78	Fan #6, % time	V-sensor #6		miniLAB1008-1	18	0/5 VDC
79	Fan #7, % time	V-sensor #7		miniLAB1008-1	19	0/5 VDC
80	Fan #8, % time	V-sensor #8		miniLAB1008-1	20	0/5 VDC
81	Fan #9, % time	V-sensor #9		miniLAB1008-1	21	0/5 VDC
82	Fan #10, % time	V-sensor #10		miniLAB1008-1	22	0/5 VDC
83	Fan #11, % time	V-sensor #11		miniLAB1008-1	23	0/5 VDC
84	Fan #12, % time	V-sensor #12		miniLAB1008-1	24	0/5 VDC
85	Fan #13, % time	V-sensor #13		miniLAB1008-2	0	0/5 VDC
86	Fan #14, % time	V-sensor #14		miniLAB1008-2	1	0/5 VDC
87	Fan #15, % time	V-sensor #15		miniLAB1008-2	2	0/5 VDC
88	Fan #16, % time	V-sensor #16		miniLAB1008-2	3	0/5 VDC
89	Fan #17, % time	V-sensor #17		miniLAB1008-2	4	0/5 VDC
90	Fan #18, % time	V-sensor #18		miniLAB1008-2	5	0/5 VDC
91	Fan #19, % time	V-sensor #19		miniLAB1008-2	6	0/5 VDC
92	Fan #20, % time	V-sensor #20		miniLAB1008-2	7	0/5 VDC
93	Fan #21, % time	V-sensor #21		miniLAB1008-2	8	0/5 VDC
94	Fan #22, % time	V-sensor #22		miniLAB1008-2	9	0/5 VDC
95	Fan #23, % time	V-sensor #23		miniLAB1008-2	10	0/5 VDC
96	Fan #24, % time	V-sensor #24		miniLAB1008-2	11	0/5 VDC
97	Fan #25, % time	V-sensor #25		miniLAB1008-2	12	0/5 VDC
98	Fan #26, % time	V-sensor #26		miniLAB1008-2	13	0/5 VDC
99	Fan #27, % time	V-sensor #27		miniLAB1008-2	14	0/5 VDC
100	Fan #28, % time	V-sensor #28		miniLAB1008-2	15	0/5 VDC
101	Fan #29, % time	V-sensor #29		miniLAB1008-2	16	0/5 VDC
102	Fan #30, % time	V-sensor #30		miniLAB1008-2	17	0/5 VDC
103	Fan #31, % time	V-sensor #31		miniLAB1008-2	18	0/5 VDC
104	Fan #32, % time	V-sensor #32		miniLAB1008-2	19	0/5 VDC
105	Fan #33, % time	V-sensor #33		miniLAB1008-2	20	0/5 VDC
106	Fan #34, % time	V-sensor #34		miniLAB1008-2	21	0/5 VDC
107	Fan #35, % time	V-sensor #35		miniLAB1008-2	22	0/5 VDC
108	Fan #36, % time	V-sensor #36		miniLAB1008-2	23	0/5 VDC
109	Fan #37, % time	V-sensor #37		miniLAB1008-3	0	0/5 VDC
110	Fan #38, % time	V-sensor #38		miniLAB1008-3	1	0/5 VDC
111	Fan #39, % time	V-sensor #39		miniLAB1008-3	2	0/5 VDC
112	Fan #40, % time	V-sensor #40		miniLAB1008-3	3	0/5 VDC
113	Fan #41, % time	V-sensor #41		miniLAB1008-3	4	0/5 VDC
114	Fan #42, % time	V-sensor #42		miniLAB1008-3	5	0/5 VDC
115	Fan #43, % time	V-sensor #43		miniLAB1008-3	6	0/5 VDC
116	Fan #44, % time	V-sensor #44		miniLAB1008-3	7	0/5 VDC
117	Fan #45, % time	V-sensor #45		miniLAB1008-3	8	0/5 VDC
118	Fan #46, % time	V-sensor #46		miniLAB1008-3	9	0/5 VDC
119	Reserved			miniLAB1008-3	10	
120	Reserved			miniLAB1008-3	11	

Table 4. (continued)

Data Col	File heading	Sensor/controller	Range	DAC hardware	Ch#	Signal or EV
121	Reserved			miniLAB1008-3	12	
122	Reserved			miniLAB1008-3	13	
123	Reserved			miniLAB1008-3	14	
124	Reserved			miniLAB1008-3	15	
125	Reserved			miniLAB1008-3	16	
126	Reserved			miniLAB1008-3	17	
127	Reserved			miniLAB1008-3	18	
128	Reserved			miniLAB1008-3	19	
129	Reserved			miniLAB1008-3	20	
130	---	Solenoid 1		FP-DO-401-1	0	24 VDC
131	---	Solenoid 2		FP-DO-401-1	1	24 VDC
132	---	Solenoid 3		FP-DO-401-1	2	24 VDC
133	---	Solenoid 4		FP-DO-401-1	3	24 VDC
134	---	Solenoid 5		FP-DO-401-1	4	24 VDC
135	---	Solenoid 6		FP-DO-401-1	5	24 VDC
136	---	Solenoid 7		FP-DO-401-1	6	24 VDC
137	---	Solenoid 8		FP-DO-401-1	7	24 VDC
138	---	Solenoid 9		FP-DO-401-1	8	24 VDC
139	---	Solenoid 10		FP-DO-401-1	9	24 VDC
140	---	Solenoid 11		FP-DO-401-1	10	24 VDC
141	---	Solenoid 12		FP-DO-401-1	11	24 VDC
142	---	Solenoid 13		FP-DO-401-1	12	24 VDC
143	---	Reserved		FP-DO-401-1	13	
144	---	Reserved		FP-DO-401-1	14	
145	---	Reserved		FP-DO-401-1	15	
146	---	Calibration gas-1		FP-DO-401-2	0	24 VDC
147	---	Calibration gas-2		FP-DO-401-2	1	24 VDC
148	---	Calibration gas-3		FP-DO-401-2	2	24 VDC
149	---	Calibration gas-4		FP-DO-401-2	3	24 VDC
150	---	Calibration gas-5		FP-DO-401-2	4	24 VDC
151	---	Reserved		FP-DO-401-2	5	
152	---	Reserved		FP-DO-401-2	6	
153	---	Reserved		FP-DO-401-2	7	
154	---	Reserved		FP-DO-401-2	8	
155	---	Reserved		FP-DO-401-2	9	
156	---	Reserved		FP-DO-401-2	10	
157	---	Reserved		FP-DO-401-2	11	
158	---	Reserved		FP-DO-401-2	12	
159	---	Reserved		FP-DO-401-2	13	
160	---	Reserved		FP-DO-401-2	14	
161	---	Reserved		FP-DO-401-2	15	

SOP 16. Gravimetric TSP Samplers

Introduction

Because the air is generally moving at velocities above 1.0 m/s near the fans in barns it is necessary to sample particles isokinetically to reduce measurement error. The airflow patterns near these fans are not straight or uniform, thus making traditional isokinetic sampling difficult. Additionally, there is evidence that particle concentration may vary significantly at different locations near a fan. The system used here tries to minimize the error associated with these non-ideal conditions while considering the practical and physical constraints of sampling in an animal environment. While existing EPA particle sampling standards have been incorporated when possible, special considerations for exhaust fans in livestock barns are considered. This system, described further below, consists of an isokinetic sampling head attached to a 37-mm open-faced filter holder. The flow rate is controlled by a critical venturi, which maintains a set flow rate. This setup allows several sampling points (head and venturi) to be sampled using a single pump. With this system, three points across a single fan in each barn will be sampled. All components are labeled in the separate TSP sampling system assembling diagram.

TSP Sampling System Installation

A practice assembly in the laboratory is advised to make sure all the necessary parts and tools are inventoried before proceeding to the field.

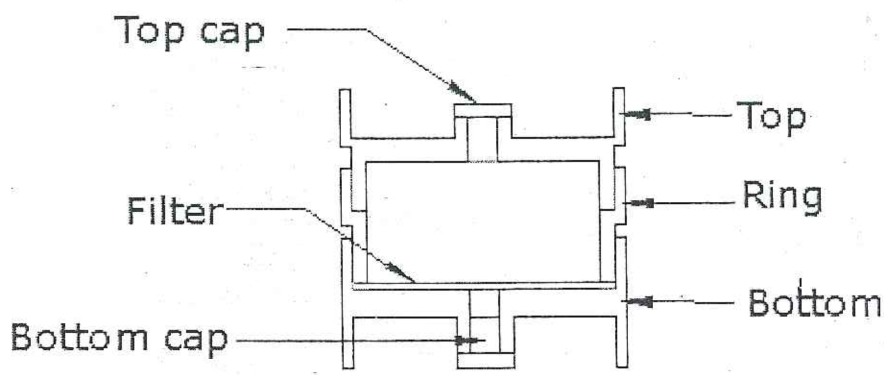
There are three assemblies that are described below. The first is the Filter Holder Assembly, which consists of only the clear plastic filter holder (3 pieces and caps) and the filter. The TSP Sampling System Assembly is the second section. This includes the Sampling Head-Filter Assembly as well as the pump and necessary fittings and tubing. The last assembly is the Sampling Head Filter Assembly. This assembly contains details of the sampling head, partial filter assembly, the critical venturi and the necessary adapters, tubing, etc. An additional section indicates where to locate the sampling heads. Instructions for leak checking are also included.

Filter Holder Assembly

The filter holder, shown below, is the container that the filter will be stored in during conditioning and travel. The filter holder is made of clear plastic and consists of three main parts, the top, ring and bottom. In addition, there are two caps that seal the tops and bottom of the holder. The bottom part is where the filter sits. The ring holds the filter down and the top will be used primarily for protection during handling.

During assembly the filter should be placed inside the filter holder with the smoother side (the side facing up when removed from the package) facing up. When handling the filters use either tweezers or wear clean powderless gloves. Place a ring inside the bottom piece and push so that the two pieces are held tightly together. It should be noted that when assembled the ring will not sit firmly against the filter so do not attempt to force the pieces to touch. This can lead to damage of the holder and cause pieces of plastic to scrape away and contaminate the filter. The ring should be tight but still fairly easy to remove. Now the top should be added and the top cap put in place. The bottom cap is optional and will need to be removed for desiccation and weighing as described later.

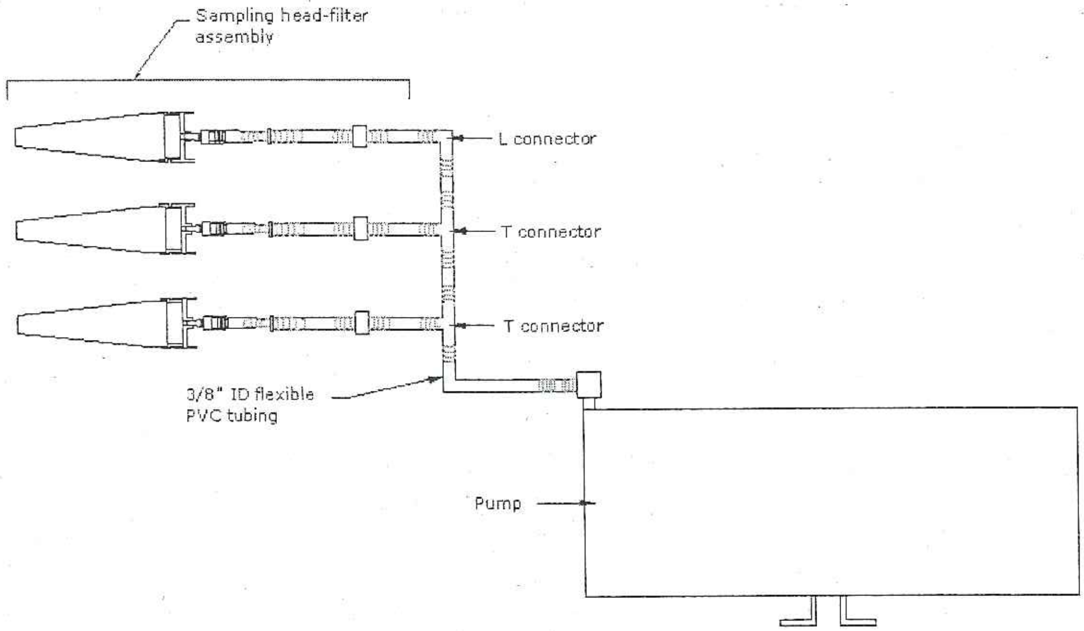
Before or after assembly, each piece (except the filter) should be labeled so that it is clear which top, bottom, etc. go with which "assembly". This will make it easier to track possible contamination later. An example would be labeling the top, ring and bottom 01T, 01R, and 01B respectively.



FILTER HOLDER ASSEMBLY

TSP Sampling System Assembly

The TSP System Assembly diagram is shown below. It shows the overall relationship of the Sampling Head-Filter Assemblies to each other and the pump. This drawing is not to scale. The tubing is likely to be longer and the heads further apart. The final setup is left up to each user. A description of the sampling head locations is included later to help guide the installation process. The sampling heads will need to be held in place. Probably the easiest way to do this is with a ring stand with adjustable arms and clamps that will allow precise positioning of the system. In some cases it may be necessary to suspend the stand from the ceiling or use a different method all together. In any case, the criteria outlined in the Sampling Head Location section must be met.



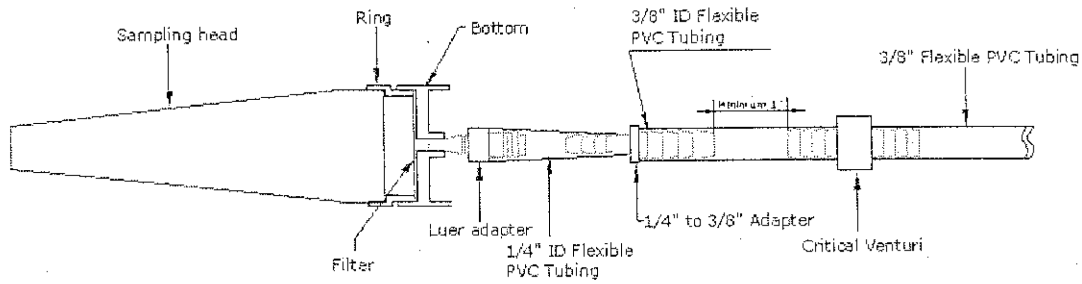
TSP SAMPLING SYSTEM ASSEMBLING DIAGRAM

Sampling Head-Filter Assembly

The Sampling Head-Filter Assembly is shown below. This is probably the most critical portion of the TSP sampling system and is therefore shown as a separate section. This section consists of the sampling head, a partial filter holder assembly, the critical venturi and the necessary tubing and fittings.

When setting up the initial system, the section up to the filter holder (from the right) will be assembled first. The assembly should resemble the diagram below. The Luer adapter is a fitting that fits inside the bottom of the filter holder and connects it to ¼" tubing. The ¼" tubing then needs to be transitioned to 3/8" tubing, using the provided adapters, so that the critical venturi can be inserted. There should be a minimum of one inch between the venturi and any other fittings to allow for the proper air flow development. The section described thus far will be a relatively permanent installation. Once installed, there will be minimal need to change this section.

On the other hand, the sampling head and filter holder will be removed and changed during every sampling round. The filter holder section used is the same as the filter holder assembly described above with the top portion and the bottom cap removed. The aluminum sampling head is then inserted into the ring (similar to the way the top was) so that it fits snugly. The filter holder bottom is then placed onto the Luer adapter. This section is now complete. The exact procedure for installing the heads and starting sampling is described later.



SAMPLING HEAD-FILTER ASSEMBLY

Location

The location of the sampling heads will be determined by the local air velocity and location relative to the fan. The local air velocity refers to the face velocity at the sampling head. The local air velocity should be measured and a plane chosen where the velocity equals the design isokinetic sampling velocity of the head, within 10%. Generally, this velocity should be within two diameters of the fan. One nozzle should be located directly in front of the center of the fan. The other two nozzles should be located near the outer edge of the fan, one near the top edge, and one near the bottom edge. The specific location will depend on the distance upstream of the fan. The farther upstream the nozzle has to be to meet the isokinetic criteria, the farther from the center of the fan the head can be. All heads do not have to be on the same plane but they should all be on the same velocity contour to ensure isokinetic sampling. Depending on the velocity contours of the fan this may or may not be a plane. The nozzles should generally face away from the fan. If the direction of the air stream deviates significantly from perpendicular to the fan then the nozzles can be angled to face into the air stream. In addition, the nozzles should not be located within 0.3 m of the TEOM sampling head to minimize its effect of the airflow near the nozzles. The final layout should be discussed with the QA/QC coordinator for approval.

Equipment

1. Sampling rate at each point: Q = 20 L/min
2. Flow control: critical flow venturi controller. One pump for three sampling locations;
3. Filter specs: 90-124 mm Borosilicate glass filters (e.g., Pall-Gelman)
4. Filter holders: reusable filter holders with removable caps that can be used for transporting and will minimize dust mass loss during handling.
5. Pump specification: 60 L/min (3x20 L/min) at up to 20 kPa pressure.

Summary of Sampling Procedure

1. Pre-dry (or equilibrate) the filters for at least 24 h, weigh the filters three times and use the average (discuss the availability of facilities with the group)
2. Place and store the filter in a filter holder with a sealed cap;
3. Install the filter holder assembly at the proper sampling point, each filter will face up and tilted away from the fans at a 10 degree angle and remove the cap.

4. Start the air pump and record the starting time.
5. Recommend collecting weekly samples to allow sufficient mass for accurate gravimetric analysis. More frequent (and possibly less frequent) filter changes may be required depending on the dust concentrations.
6. At the end of sampling period, replace the cap and remove the filter holder assembly.
7. Dry (or equilibrate) the exposed filters for at least 24 h, then weigh the samples again.
8. Data analysis – TSP concentration

Basic QA/QC

1. Blanks: precondition, weigh, place in filter holder with cap, remove, recondition, and reweigh.
2. Field blanks: Go through the same process as the other filters, including placing on the sampler and removing the cap. The cap is then replaced and treated as an exposed filter.
3. Leak test after initial installation and after any significant system changes. Install filter holder assembly onto each sampling point (excluding bottom cap) with top cap in place to seal system. Install flow meter (e.g., rotameter with MDL<1 L/min) on pump exhaust and operate pump. Requirements: Vacuum >25 in Hg and flow < 1 L/min.
4. Flow audit. The venturis were calibrated at UIUC using a frictionless flow calibrator (BIOS Dry Cal 2), but the flow must be verified in the field. Before sampling, replace sampling nozzle with filter holder top, and connect it to a flow measurement device with a tube. Operate pump and take at least three readings. This average should be within 5% of calibrated flow rate. The actual difference in flow rate will likely be around 3-5% lower due to friction of flow audit system. If flow >5% check setup and conduct calibration calculations. If the flow rate still >5% then check sampling system for leaks past the flow meter.

Filter Conditioning, Weighing and Handling

Handling

Care should be taken to avoid damage during handling. Clean filters are to be kept from the exposed filters as much as possible and handling is to be done using appropriate tweezers and gloved (clean and powderless) hands. During the initial preconditioning (described below), the filters can be left in their original packaging. Before being weighed, each filter should be placed in a uniquely labeled filter holder. Each piece of the filter holder should be labeled. The filter should remain in this holder until all conditioning, sampling and weighing has been completed. It is recommended that the filters and holders be archived for at least two more sampling rounds in case further analysis is necessary. Special requests may be made for collected samples to be sent to another university for further analysis. These requests will be made in advance to ensure the filters are saved.

Preconditioning and Weighing

Weigh each filter in their own holder. Only the bottom part of the filter holder will be used during weighing. During storage and transportation, the entire filter holder (including the top cap) should be used to protect the filter from contamination. During drying and weighing, the bottom cap should not be used to allow for faster drying and higher weighing accuracy.

Filters and labeled holders should be conditioned in a desiccant drier for at least 24hoursbefore being weighed at a temperature of 20 ± 5.6°C. For weighing, the filters should be placed in their filter holders. Weights should be taken every six hours until the weight stabilizes to within 0.005 mg (approximately 0.1% of the filter mass) of the previous weight. The weight should be recorded to the nearest 0.001 mg.

The scale used should be able to weigh up to 9,999 mg with a precision down to 0.001 mg. This gives an expected precision of 1% under normal sampling conditions for a 24-h period. If longer times or dustier conditions are expected then lower precision scales may be used.

Three replications of the weight should be made. Before each replication, the door to the scale should be closed and the scale zeroed. The door is then opened, the filter and holder placed in the tray and the door closed again. When the weight indicator stabilizes, the reading is to be recorded, the door opened and the filter and holder is removed. The process is then repeated after closing the door.

Sampling

Sampling Time and Frequency

Sampling times will be determined by dust loading and time constraints. The maximum sampling time may be as long as two weeks for low dust concentration environments.

When accessing the pump is difficult, a timer may be used to turn it on and/or off. This method should primarily be used for turning the pump off so that the technician can make sure the system is connected and running properly when it is started.

Velocity Check

Before sampling begins, the velocity should be checked to make sure that it is within 10% of the nozzle design velocity. Previous experience should be used to determine if the velocity is likely to deviate significantly from this velocity (i.e. for variable speed fans). The specific distance from the fan should be determined and set based on these readings and previous experience.

Removing Filter Holders and Sampling Heads

If necessary, first remove the old holder. When doing so make sure to leave the Luer adapter in the tubing by pulling the old filter holder off of it rather than pulling the Luer adapter from the tubing. Be careful when handling the filter holder and try to always keep it upright after it has been exposed. There will likely be a significant dust cake, which can easily fall off if the filter is turned over or shaken up. Considering this, remove the isokinetic nozzle without removing the filter holder ring. Set the head aside and place the original lid for the filter holder back on. The nozzle should be cleaned periodically, preferably every sampling round, using a compressed air duster and/or a lint free cloth. This will help ensure that there is no residual contamination of the next sample.

Installing Filter Holders and Nozzles

To install a new filter holder, first remove the lid and set aside. Insert the cleaned (see the removal procedure above) isokinetic head and make sure that all parts are secure. Insert the Luer adapter into the bottom of the filter holder and secure the nozzle assembly so that it is fixed at the correct location and in the correct orientation. After installing all holders and nozzles, make sure the system is complete and that the heads are not likely to move during sampling. When finished installing the heads, record the location (i.e. top, middle or bottom and which room) for each filter holder.

Sampling

After everything has been installed, get ready to leave the area to prevent stirring up extra dust. Conduct a visual check of the system to make sure there are no cracks or pinches in the tubing and that all of the fittings are secure. If using a timer, set the timer to turn off at the desired time (multiple of 24 h). Turn on the pump and record the time and any other conditions of interest. Do an audible check to make sure the pump is running and that each nozzle is being sampled.

SOP 18 - MANURE SAMPLING

May 7, 2004

Methodology

Monthly manure samples will be taken and sent to Purdue University's Manure Analysis Laboratory (Dr. Alan Sutton, Director) and analyzed for pH and moisture content (see SOP 19), which are the two major factors affecting ammonia emissions. Thirty-six (36) surface samples will be collected from randomly selected locations in each barn.

In the deep pit barns, thirty-six (36) surface samples will be collected from the top 5 cm of the stored litter at randomly selected locations. In the belt-battery barn, samples sixteen (16) samples will be collected from the manure belt at randomly selected locations.

Samples will be put into a zip-locked plastic bag that is labeled using a permanent marker with a unique number prior to the sampling procedure. All sample custody procedures will be followed.

Manure Sampling Matrix

	Mt. Victory	Croton
Sampling interval, days	30	30
No. of samples per yr	6	6
No. of samples/barn	36	16
Number of barns	2	1
Number of samples	432	96

SOP 19 – Manure Evaluation

Purdue University Manure Analysis Laboratory
Revised May 5, 2004

Total Solids, Volatile Solids, Fixed Solids

Procedure

- Run all samples in duplicate
- Weigh empty clean crucible (crucible empty weight)
- Carefully mix sample with a sampling pipette and and carefully pipette into the crucible
- Weigh crucible again (crucible + sample weight)
- Put in oven to dry overnight at 90□ C to 95□ C
- Remove crucible from oven with tongs and place in the desiccator to cool
- Weigh cooled crucible (crucible + dry)
- Place crucible in the muffle furnace and raise temperature to 550□ C for 3 hours
- Remove crucible from the muffle furnace and place in the desiccator to cool
- Weigh crucible (crucible + ash)

Calculations

- (Dry wt)/(Sample Wt) * 100 = % Total Solids
- (Ash Wt)/(Dry Wt) * 100 = % Fixed Solids
- 100% – % Fixed Solids = % Volatile Solids
- 100 - % Total Solids = % Moisture

pH

Procedure

1. Check electrode to be sure KCl electrode is being used. Lower plastic band covering hole on electrode.
2. Check to see that machine is on standby and lift electrode from soaking solution.
3. Rinse electrodes with redistilled water into a waste beaker with a wash bottle.
4. Place small quantity of pH 7 buffer in 50 ml beaker, submerge electrodes, turn machine to pH. Wait for a stable display and calibrate.
5. Rinse electrode with redistilled water into a waste beaker with a wash bottle.
6. To do a 2-step calibration, place a small amount of pH 4 or 10 into a 50 ml beaker each, wait for a stable display and calibrate using the procedures above.
7. Rinse electrode with redistilled water into a waste beaker with a wash bottle.
8. Place quantity of solution to be tested in beaker; when stable record the value.
9. Rinse electrode between samples with distilled water into waste beaker with a wash bottle.
10. When finished, submerge electrode in storage solution and placing machine on standby.
11. Add saturated KCl solution to electrode when needed and make sure electrode is submerged at all times when not in use.

For solid samples, pH meter setup is the same.

1. Weigh 4 g. of solid waste into 50 ml beaker.
2. Add 30 ml of redistilled water and let set 30 minutes.
3. Use small stir bar to mix solids with water and determined pH as above.

Ammonium (NH_4^+) by Steam Distillation

Operation of Steam Distillation Apparatus

1. Make sure there are glass beads or boiling stones in 5-L steam generation flask.
2. Turn cold water to condensers on.
3. Steam the apparatus for approximately 10 min before use to remove potential traces of NH_3.
4. Adjust rate of steam generation to collect 4-5 ml of distillate per minute with lab timer.
5. Add more water to 5 L flask when water level reaches the ½ full mark.
6. Keep steam by-pass tube open when not distilling a sample.

Procedure

NH_3-N

1. Add 5 ml of boric acid indicator to 50 ml Erlenmeyer flask marked to indicate volume of 30 ml of condensed distillate.
2. Place flask under condenser of steam distillation apparatus so that the end of the condenser is about 4 cm above the surface of the boric acid.
3. Place an aliquot of sample into the distillation flask. (5 ml for Total Nitrogen analysis [SOP 13], 1-2 g of waste for NH_3–N analysis)
4. Add 15 ml of 10N NaOH for Total Nitrogen, 10 ml distilled water + 10 ml 10N NaOH in waste samples for NH_3–N
5. Add small quantity of MgO using measured spatula that is provided to the distillation flask.
6. Attach flask to distillation apparatus.
7. Commence distillation by closing stopcock on the steam by-pass tube of the apparatus.
8. When the distillate reaches the 30-ml mark on the receiver flask, stop the distillation by opening the stopcock on the steam by-pass tube, rinse the end of the condenser with deionized distilled water in a wash bottle.
9. Determine NH_3–N in the distillate by titration with 0.05N H_2SO_4. End point = green to permanent, faint pink.

Reagents

Boric acid indicator (for 20 L): 400 g boric acid, 4 L 95% ethanol, 15,600 ml redistilled water
400 g mixed indicator, 0.05N H_2SO_4, 1.337 ml conc H_2SO_4/L or 26.74 mL/20 L
Mixed indicator: 0.330 g bromocresol green, 0.165 g methyl red, 500 ml 95% ethanol
Magnesium oxide: ignited to 600°C and cooled.

Reagent Preparation

Boric acid indicator (20 L)

1. Dissolve 400 g of boric acid in two 6L Erlenmeyer flasks (warm and stir).
2. Cool.
3. Add redistilled water to 6,000-mL mark on flask
4. Quantitatively transfer to 20-L jug. Use 1,000 ml (500 ml each) redistilled water to rinse out the erlenmeyers.
5. Add 4,000 mL 95% ethanol and mix with electrical stirrer.
6. Add 400 mL. of mixed indicator and mix with electrical stirrer.
7. Add 1,000 mL redistilled water to wash down wall of jug. Mix well with electrical stirrer.
8. Test for end point and adjust with 1N NaOH. End point is when a color change from pink to pale green is just detectable when 1 mL of the boric acid solution is treated with 1 mL of redistilled water.
9. Add 1,600 mL redistilled water and mix with electric stirrer.

Magnesium oxide

Ignite in a muffle furnace at 600-700°C for 2 h. Cool in desiccator containing KOH pellets and store in tightly-stoppered bottle.

Standardization of 0.05N H_2SO_4

Add 2.65 g of oven-dried Na_2CO_3 to a 1-L volumetric flask and bring up to volume with redistilled water. This is a standard 0.05N solution.

Accurately pipette 5 mL of 0.05N Na_2CO_3 in a 50-mL flask.

Add 2 – 3 drops of mixed indicator to each erlenmeyer flask.

Titrate with standard H_2SO_4 to end point.

Repeat until 4 to 6 trials have been recorded.

Calculate acid normality as follows:

Normality of acid H_2SO_4 = meq Na_2CO_3 x volume of acid = meq/ml

Calculation for Total Nitrogen and NH_4^+

$$\frac{\text{Corrected mLs of 0.05N } H_2SO_4 \text{ titrant x } \mu g \text{ N/ml}}{\text{g sample wt.}} \text{ x dilution (total N analysis} = \mu g \text{ N/gm}$$

Corrected mL of acid = mL titrated (sample) – avg mL titrated (blank)

µg N/mL = normality (meq.) of acid x 14 mg/atom N

Total Nitrogen

Procedure

1. Label Folin-Wu tubes; need 2 tubes per unknown sample plus 2 blanks.
2. Add 1.1 g of K_2SO_4:$CuSO_4 \cdot 5H_2O$:Se mixture to each tube.

3. Weigh 1 to 2 g of animal waste sample.
4. Add 5 ml of concentrated H_2SO_4 slowly.
5. Carefully mix the tubes with the vortex mixer.
6. Place digestion tubes in the aluminum block and place small glass funnels (25 mm diameter) in the mouth of the digestion tubes and turn on the hot plate.
7. Heat samples under the hood (MAKE SURE FAN IS ON!!!) for 3 hours after digest clears.
8. Remove tubes from aluminum block with tongs and allow to cool to room temperature.
9. Dilute digests with redistilled water to approximately 50 ml volume, let cool and bring up 50 ml volume, stopper the tube and mix well with a vortex mixer.
10. Pipette an aliquot of the diluted digest (generally 5 ml) to a 100 ml steam distillation flask.
11. Steam distill and determine NH_4-N as described in the NH_3-N procedure.

Reagents

K_2SO_4:$CuSO_4 \cdot 5H_2O$:Se mixture at ratio of 100:10:1.

SOP 20. Data Management at IS

The objectives of data management are to:
1. Ensure data security;
2. Provide convenient data retrieval;
3. Minimize labor and cost involved in data management, and
4. Minimize possible interference with the on-going data acquisition.

Classification of computer files (with level "1" as the most important):

Management of data files, and method and frequency of file backup should depend on the importance of the files.

1. Unique files created before or during the project. These files, once lost, usually cannot be rebuilt. They include:
   - Measurement data
   - Calibration data (data recorded by LabVIEW and calibration sheets in electronic forms)
   - Downloaded instrument data, e.g. TEOM
   - Field notes
   - Email messages
   - Image files (digital photos or computer screen shots) relevant to the project

2. Program files and system configurations created for the project. These files, once lost, will require extra time to rebuild or recover. They include:
   - LabVIEW data acquisition and control program.
   - Configuration files for data acquisition and control hardware (e.g. FieldPoint, DAS 1602 / EXP 32 configuration files).
   - Configuration files of sampling sequence for actuating solenoids.
   - Firewall configurations, etc.
   - Email message rules.
   - Favorites lists

3. Specific software and documents needed for the project. These file are provided by manufacturers. They can usually be obtained on the internet or from the manufacturer by request, but having them ready on the computer will increase working efficiency. They include:
   - Instrument manuals.
   - Software like FieldPoint, InstaCal, TEI for windows, etc.

4. Operating system (installed and configured Windows) and installed commercial software, e.g. MS Office, PCAnywhere, etc.

Procedure

1. Arrange all project-relevant files together at an easily-found location under C: drive for backup and retrieval.
2. Arrange folder/file structure in the field PC based on file importance and file types. Each folder in the C: drive should be limited to 700 Mb size for easy backup in a single CD. Figure 1 shows an example for the APECAB project, in which the folder "APECAB data unzipped 2" is made because "APECAB data unzipped" already contains 700 Mb data.

Figure 1. An example of field PC folder structure.

3. Make records of the LabVIEW program settings and coefficients whenever there are changes. Most settings and coefficient data are recorded in the Settings.txt file. An alternative method is to make screen shots of part of the LabVIEW program including diagram and front panels that have been changed.
4. Use the LabVIEW automatic email feature to email data files that LabVIEW acquired daily to the campus at midnight.
5. Email calibration sheets and calibration control chart to campus each time after calibration.
6. Back up the project folder in the field computer on a CD every two weeks or when there are changes in Levels 2 or 3 data.
7. Back up the operating system (Level 4 data) when there are significant changes in the system.
8. Store the backup CDs in a location other than the field lab.

SOP 21. FANS Analyzer

Purdue Agricultural Air Quality Laboratory (PAAQL)
July 11, 2002. Revised May 7, 2004

Introduction

A device for in-situ exhaust fan airflow capacity measurement, called the Fan Assessment Numeration System (FANS) device, previously developed and constructed at the USDA-ARS Southern Poultry Research Laboratory, was refined and constructed by University of Kentucky (contact Dr. Rich Gates, 859-257-3000). It is designed to measure the total airflow rate of a ventilation fan by measuring the flow speed across the entire fan. The FANS incorporates an array of five propeller anemometers to perform a real-time traverse of the airflow entering fans of up to 137 cm (54 in) diameter. This document provides instructions on installation of the program and operation of the FANS Analyzer, and will help in producing high quality measurements.

Preparation

Data Acquisition Computer

Before using the FANS Analyzer, it is necessary to prepare a computer with the necessary hardware to link with the FANS Analyzer and software to control and record data. For this, a Keithley DriverLINX card, and the WildCat Anemometer Program will be needed. *The installation procedures that follow were provided by Ken Casey of the University of Kentucky.*

Installing Keithley DriverLINX and Anemometer Program

1. Close down all background applications of the computer to be installed.
2. Insert Keithley Card into PCMCIA.
3. Insert the Keithley DriverLINX CD and run the autostart program with command "setup.exe"
4. After the installation window appears, click *"Install DriverLINX"*:
    a. Click *"Install Drivers"* – c:\Program Files\DrvLINX4
       and follow directions for registration, use defaults
    b. Click "Install Interfaces" – same procedures as step a.
       Be sure to select all options (three of them)
       Use default folder.
    c. Click *"Install Documentation"* – use default folder.
5. Click *"Back"*, *"Exit"*, and *"Done"*
6. Your computer will be restarted.
7. Once restarted, a screen should come up for hardware configuration:
    a. Follow step 2. Plug & Play should install drivers
    b. Wait some time for response
        - Afterwards – click *"continue"*, follow directions

- Probably, click *"configure"*

8. Under hardware configuration
    a. Assign logical device number (the default – probably 0)
    b. Leave all other values at default, click *"OK"*, and close window.
9. Remove Keithley Card, wait about 10 seconds
10. Reinsert card, click "*Start*", "*Programs*", "*DriverLINX*", "*Test Panels*"
    a. Run the AIO Panel
        - If it says "No Driver loaded" – reboot, ignore the rest of installer and restart AIO Panel.
        - You should be ready to run
        - You may need to tweek in *"DriverLINX Configuration Panel"*
11. Copy *Anememeter2.exe* and *Anememeter2.mdb* from floppy disc supplied into your directory.

FANS Analyzer Unit

In order to ensure the FANS Analyzer is operating properly, first operate the unit manually.

1. Supply the FANS Analyzer with power.
2. Right-most toggle switch should be in up position.
3. Toggle left-most switch up and down, holding for a few seconds at a time to ensure that the motor is moving the anemometers properly.

If all is working properly, then place the individual propellers onto the unit. The propeller can not be installed at the bottom position due to limited space, therefore the holder must be at least six inches or more from the bottom. Make sure that the number of the propeller and of the open-vane anemometer match (there are five in all, and the numbers are marked on both).

Operation

Placing the FANS Unit

After selecting the fan to be measured, place the FANS stand (a metal frame made with adjustable weather tower poles) in front of fan, adjust the height, and level it using boards or other appropriate material. After it is leveled, check to ensure it remains stable. If not, then take steps to provide stability before continuing.

When the stand is level and stable, place the FANS Analyzer onto the stand, and center it with respect to the fan. This will be quite easy if measuring on the intake side of the fan. However, if measurements will be taken on the outlet, the fan guard must be dealt with. Since the guard is cylindrical, the four corners of the FANS Unit should be equidistant from the edge of the fan guard.

Connecting the FANS Unit

After the FANS Analyzer has been properly placed, connect the FANS Analyzer to a power supply, and turn on. Connect the computer to the FANS Unit via the already installed Keithley PC card and the 37-pin serial cable.

When the computer and the FANS Analyzer are connected, start the program "Anemometer2". After the Anemometer 2 window shows up, press "motor up" or "motor down" to see if the FANS Analyzer is communicating with the computer. Make sure the anemometers were brought back to either top or bottom before stating the measurement.

Operating the FANS Unit

If everything is working properly, start the measurement by pressing the "Begin Data Acquisition". It will take 186 s to take one airflow reading. Running between 7 and 15 samples per fan is sufficient for analysis. Usually, the less consistent the preliminary data is, the more readings are taken. Make sure to record the data the program outputs, because by the completion of the following measurement, the data will be discarded and cannot be retrieved.

> Note: It is important to note all observations and changes that could affect the pressure at that fan, such as changes in number of fans operating during measurement, changes in wind direction and velocity, and any other factors that could alter the airflow of the fan.

Finishing

When measurements are complete at a particular fan and another will be measured, disconnect the computer and the power from the FANS Analyzer, move to the next fan, and repeat the steps in "Operation" section.

If sampling has been completed for the day, disconnect the Analyzer, and place all items in a protected location, such as the trailer.

SOP 22. Instrument Shelter

Instrument Placement

Instrument racks should be constructed of steel and be able to accept sliding trays or rails. Open racks help to keep instrument temperature down and allow air to circulate through easily. The racks should have four wheels.

Shelter Maintenance

The following should be conducted on a regular basis:

- Floor cleaning. Waxing should be done annually or between long projects.
- Air conditioner cleaning, testing, recharging, and replacement, if necessary.
- AC filter replacement.
- Supply air filter replacement including charcoal media.
- General cleaning.
- Weed abatement.
- Roof inspection and repair.

Site Log

A site log should be kept at the instrument shelter. Whereas technical details belong in the instrument logs, the site log is a chronology of events that occur at the monitoring site and a narrative of problems and solutions to problems. Items in this log should include:

- Date, time and initials of person(s) who have arrived at the site.
- Brief description of weather.
- Brief description of exterior of site, e.g. anything unusual.
- Brief description of the barns, e.g. anything unusual, production status.
- Description of work accomplished at the site.
- Detailed information about the instruments needed for repairs or troubleshooting.

Routine Operations

A table of routine operations should be prepared and posted to the wall of the IS. These are duties that must be performed in order to efficiently operate a monitoring site. Each item should have an associated frequency.

Environmental Control

The shelter, Figure 1, should be ventilated with outside air. The outside air of 25 to 100 cfm must flow through a filter to remove particulate matter and an activated carbon filter to remove odor and gases before it enters the shelter. The blower forcing air through these filters will also create a positive pressure (e.g. 5 Pa) in the shelter with respect to the air outside the shelter, thus preventing contaminated air from entering the shelter via cracks.

The electric-powered air conditioner and heater must be able to maintain the shelter temperature within the highest minimum temperature and the lowest maximum temperature of the instruments.

The temperature of the shelter must be kept above the dew point of the air being sampled. This will prevent condensation in the gas sampling system. Cool air from the air conditioner must be directed away from unheated gas sampling lines. Shelter temperature must be monitored and recorded continuously along with other variables.

Electrical Service

The environmental shelter must have sufficient electric power for the instruments in the shelter. It should be sufficiently grounded for proper operation of all equipment. The neutral to earth voltage should be tested during monitoring to determine whether it meets the requirements of the electric code. It should be less than 2 ohms. If not, corrective actions will be taken.

Other Services

Worker comfort is important for assuring quality work at the site. The IS will have a small refrigerator to store lunches, and samples, a microwave for heating refreshments, and a lavatory for washing hands.

Table 1. Specifications of the on farm instrument shelter.

Part	Size	Description
Trailer	(8 x 24 x 8 ft)	White sides, single-axle
Power cable	240 V, 50 A (each line), 100 A total	4-wire
Water		Instant water heater.
Storage	0.60 x 0.76 x 1.2 m (2 x 2.5 x 4 ft)	Storage compartment

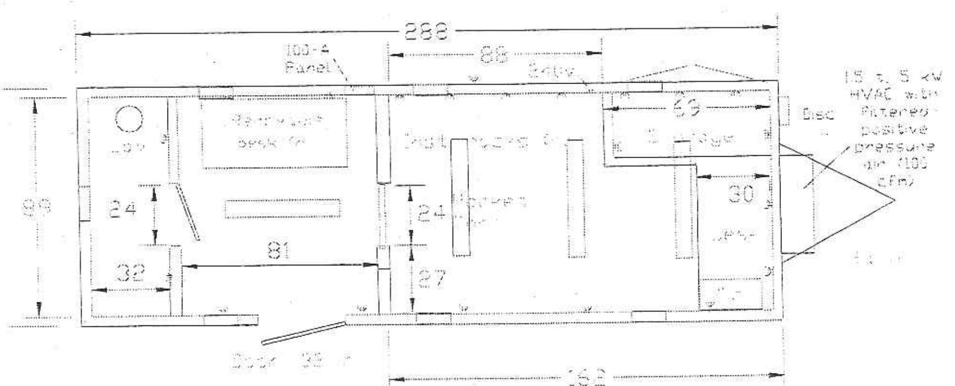


Figure 1. Floor plan of the on-farm instrument shelter.

SOP 23. Weather Station Set-Up and Operation

Introduction

This SOP describes the procedures to follow for the continuous determination of weather patterns surrounding a monitored housing unit. This SOP describes the set-up and sensors required.

Equipment Needed

1. 10 m tri-bar radio tower or roof-mounted tripod.
2. R.M. Young Wind Sentry anemometer and vane Model 03001 or equivalent.
3. Vaisala relative humidity and temperature sensor Model HMD60YO.
4. Shielded enclosure for RH/T sensor.
5. LI-COR Model LI200X pyrometer or equivalent.

Procedures

The standard tower height for recording wind speed and direction is 10 m (32.8 ft). The tower plus extension arm or roof-mounted tripod should be placed such that the anemometer and wind vane are at this height above the ground, preferably in an obstruction-free area of 50 feet in all directions. Solar and RH/T measurements should be installed at a height of at least 1.5 m and can be located in a different location than the wind measurements.

The tower should be supported with a concrete footing of 30 inch diameter and 42 inch depth or secured with three guy-wires. The wind vane must be positioned for true north using the following directional requirements (with a dead-band of no more than 5 degrees):

Wind From	Degrees
North	0 (or 355 to 360 with a 5 degree dead-band)
East	90
South	180
West	270

All weather station data will be permanently stored at 1-minute averaged periods. Wind direction data will include standard deviation of wind as per U.S. Weather Bureau Standards. All data will be stored with the following conventional units:

Component	Units
Wind Speed	m/s
Wind Direction	degrees as per convention listed above
Temperature	C
Relative Humidity	%
Solar	W/m^2